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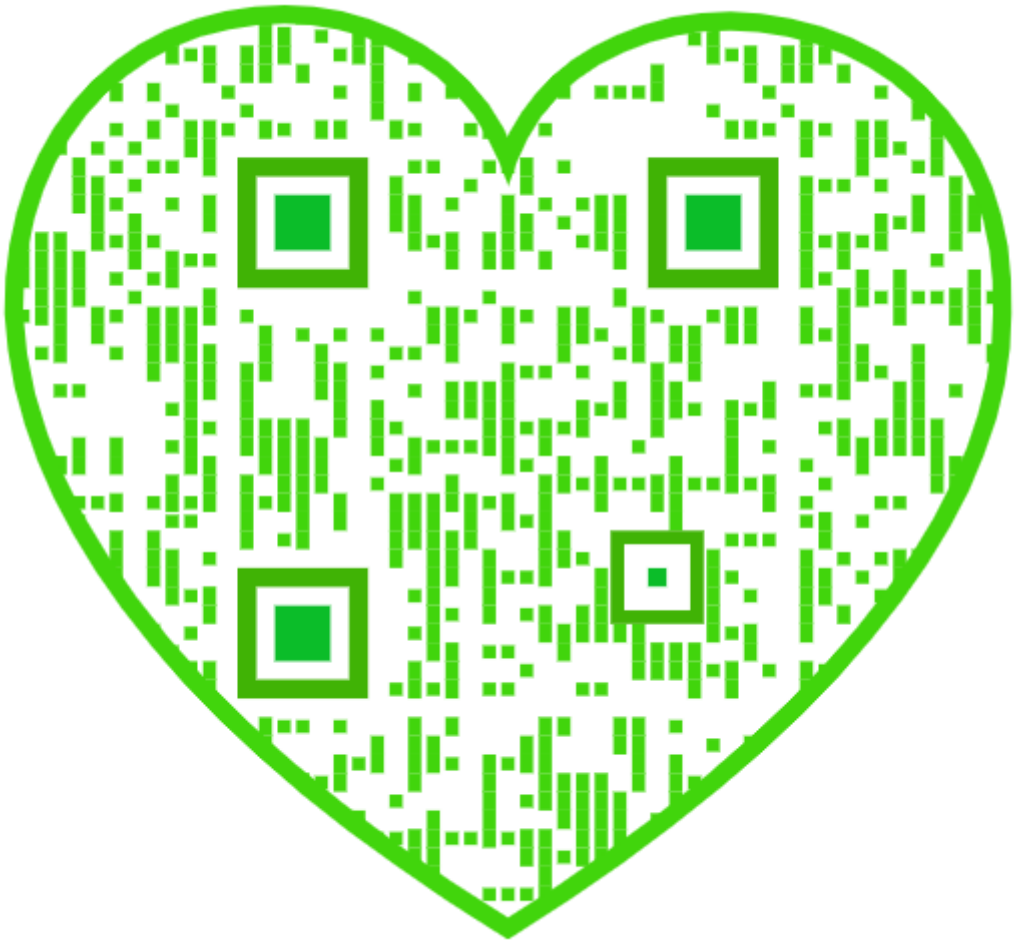
IMPERIAL

Welding and Cutting HAND BOOK

OXY-ACETYLENE
OXY-HYDROGEN
CARBON BURNING

THE IMPERIAL BRASS MFG. CO.
1200 W. HARRISON ST. CHICAGO



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Price, $1.00 per copy

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PREFACE

With proper or intelligent use, Imperial Apparatus is practically indestructible. So far as engineering knowledge, carefully selected materials, modern machinery and skilled mechanics can make them, the regulators, gauges, torches and other parts which comprise the equipment, are built for service—to give the proper kind of a flame and to stand up under ordinary wear year in and year out.

We have done our part; but unless you acquire an elementary knowledge of the apparatus, its use and how to properly keep it in good working condition, the best possible results cannot be expected. To give this necessary elementary knowledge is the purpose of this booklet. Its careful reading will help to effect a better understanding of Imperial Equipment and its use and will probably save annoying mistakes, due to lack of knowledge.

The text is free from technical verbiage and while volumes could be written on the subject, we believe this covers the fundamentals. Following along the lines described, the operator will be on the way to becoming a successful user of oxy-acetylene equipment.

Following out the rules and directions of this booklet will make your work not only a success but a pleasure as well.

SUGGESTIONS FOR BEGINNERS

NE of the things NOT to do after purchasing an oxy-acetylene welding outfit is to immediately solicit work. Note that word immediately. There is no quicker way of hurting your own reputation and of giving oxy-acetylene welding a general black eye than to fall down on a job for a customer.

In several instances, novices have solicited work before their apparatus arrived. Others, without even connecting the equipment, announce they are ready for all the castings of any metal—and into the shop come malleable iron, aluminum, bronze and cast iron—metals with which the newly enlisted operator is probably unfamiliar, to be welded by a process totally different from the method he has been acquainted with.

Now the oxy-acetylene flame will certainly join all these metals, but, given the proper equipment, it is essential that some judgment and some practice be added. To practice on a customer's job means the enmity of that customer. So, before tackling oxy-acetylene on a commercial scale, put the apparatus in the back of the shop or in a separate room, master the principles and practice on scrap material. Then make a noise.

There are certain fundamental principles which must be understood and mastered before commercial welding, even upon a simple scale, is undertaken. These fundamental principles are given on the following pages, but one can't become a welder by reading alone—it is necessary to do actual welding, though reading practical articles will certainly help.

Whenever possible, by all means secure some training, a week or two, in a repair shop. If this is not possible, practice on junk material until you are competent to operate the oxy-acetylene equipment.

PRINCIPLE OF WELDING

Welding with the oxy-acetylene flame is a fusing process. With a temperature of over 6,000° F., concentrated in a comparatively small point, the flame is held on the edges to be united UNTIL THEY MELT TOGETHER. Since by this process, no hammering or compression is necessary, it is applicable to all the metals: cast iron, malleable iron, steel, aluminum, bronze and copper.

Oxygen is purchased in conveniently handled cylinders or drums which are charged to a pressure of approximately 1,800 pounds. Purity is essential to the successful and economical operation of the oxy-acetylene process and the oxygen purchased in these high pressure drums is considerably cheaper and much purer than that made by chemicals on the premises. The proper manufacture and testing of both the oxygen and acetylene cylinders is supervised by an U. S. Government commission and if ordinary precautions are employed by the user, the tank system of gases is ideal.

Acetylene in tanks is more properly known as dissolved acetylene. The cylinder is filled with a porous material and also with a liquid known as acetone, which has the quality of absorbing many times its own volume of acetylene. Acetylene, in a free state, is dangerous at pressures greater than fifteen pounds. Dissolved, however, this hazard is removed and the gas in cylinders, while costing a little more than that generated on the premises, is considerably purer, is always ready for use merely by opening the valve and requires no care. In addition, the use of dissolved acetylene makes the entire equipment portable, a feature many times of real value for repair purposes. Pressures of acetylene cylinders vary with the different manufacturers and temperatures, but the average is around 225 pounds to the square inch.

With pure gases, it is necessary that the equipment—that is, the regulators, torches, etc.—be scientifically constructed and used with intelligence to effect satisfactory results. An understanding of the principles of this equipment we believe is essential. As you become acquainted with Imperial Apparatus, you will realize with what care and precision it is constructed, how the factor of strength has been obtained without clumsiness; how we have removed every danger hazard possible except one—the human element—so that we have considered it necessary to devote a part of these instructions to the care of the apparatus.

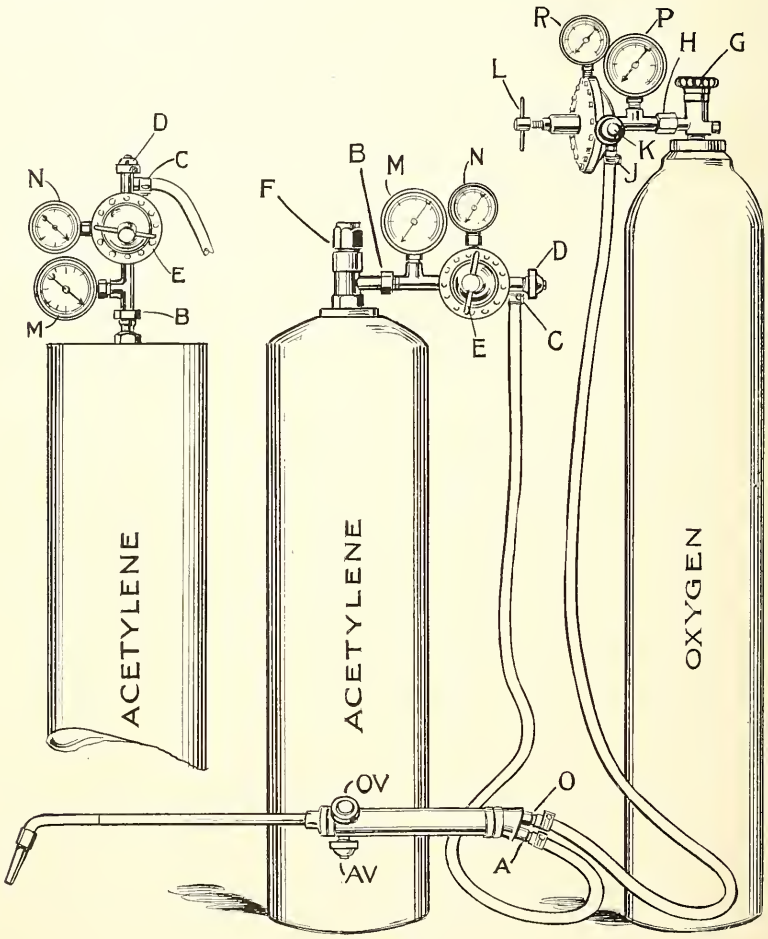


PLATE 1

SHOWING IMPERIAL WELDING OUTFIT CONNECTED TO TANKS

A—Acetylene Inlet to Torch. AV—Acetylene Valve on Torch. B—Tank Coupling. C—Hose Coupling. D—Outlet Valve to Hose. E—Acetylene Regulating Screw. F—Acetylene Tank Valve. G—Oxygen Tank Valve. H—Tank Coupling. J—Hose Coupling. K—Outlet Valve to Hose. L—Oxygen Regulating Screw. M—Acetylene Tank Pressure Gauge. N—Acetylene Working Pressure Gauge. O—Oxygen Inlet to Torch. OV—Oxygen Valve on Torch. P—Oxygen Tank Pressure Gauge. R—Oxygen Working Pressure Gauge.

Note—When either the Searchlight or Commercial Companies' Acetylene Tanks are used, the Acetylene Regulator stands out at right angle to the tank, as shown in center tank.

When Prest-O-Lite Tanks are used, the regulator stands up on end, as shown in partial view of tank at left.

CARE OF APPARATUS

OXYGEN—The use of a truck for the apparatus is very desirable. Even though the portable feature may not be desired, the oxygen cylinder should be firmly clamped or strapped to avoid falling. If, then, you are not a user of the truck, which secures both cylinders, see that the oxygen cylinder is made secure to a wall or bench, for the reason that because of its small base, it is very easily tipped over and a broken regulator would be the result.

Keep the cylinders in a reasonably cool place, away from fires or the direct rays of the sun, remembering that heat causes the gas to expand and while the factor of safety of the cylinder is a big one, it pays to be cautious.

Bear in mind that oil and oxygen under any considerable pressure make a very dangerous combination. Oil burns—oxygen is the generator and supporter of combustion; therefore, it would be quite a simple matter to secure spontaneous combustion through this combination. NEVER USE OIL ON ANY PART OF THE OXYGEN SUPPLY, the tank valve, the regulator, the connections or the torch.

Before the regulator is attached to the drum, open the valve on the cylinder quickly and close it immediately, thus blowing away any dirt that may be present on the seat of the outlet valve. If, after attaching the regulator, the valve on the drum or cylinder leaks, quickly open it as far as possible. If it still leaks, close it and take off the regulator and return the cylinder to the manufacturers, with a statement of the trouble. DO NOT ATTEMPT TO REPAIR THIS VALVE. Remember there is 1,800 pounds pressure per square inch behind it and the sudden release of this gas, caused by carelessness in repairing the valve, would probably result in an injury to the workman.

This tank valve is provided with a safety in the form of a hex.

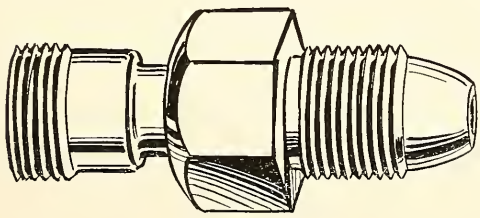


PLATE 2

Adaptor for connecting Imperial Acetylene Regulator to Prest-O-Lite 100, 150 and 300-foot Tanks

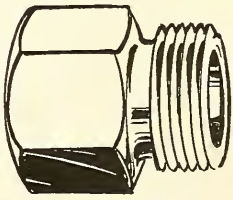


PLATE 3

Adaptor for connecting Imperial Acetylene Regulator to Searchlight or Commercial Co.'s Tanks

nut, which is sealed. The connection for the regulator is a male thread, without any nut. It would hardly seem necessary to warn the user against taking off the safety nut, yet instances have been recorded where the workman attempted to do this with very unsatisfactory results. LEAVE THE SAFETY ALONE. If it at any time leaks, return the cylinder, with a letter of explanation.

LEAKS—While oxygen itself will not burn, and has no odor, leaks should be guarded against, for the reason that oxygen will feed a fire with considerable energy.

TO USE MATCHES OR A FLAME IN FINDING AN OXYGEN LEAK IS HAZARDOUS. Soapy water used with a brush or rag may better be employed.

OXYGEN REGULATOR—As we have already learned, the initial oxygen pressure is 1,800 pounds to the square inch, decreasing, of course, as the contents of the tank are used. The pressure at the welding torch varies from a few pounds on the small tips to eighteen on the large size and in cutting reaches 125 pounds. The duty of the

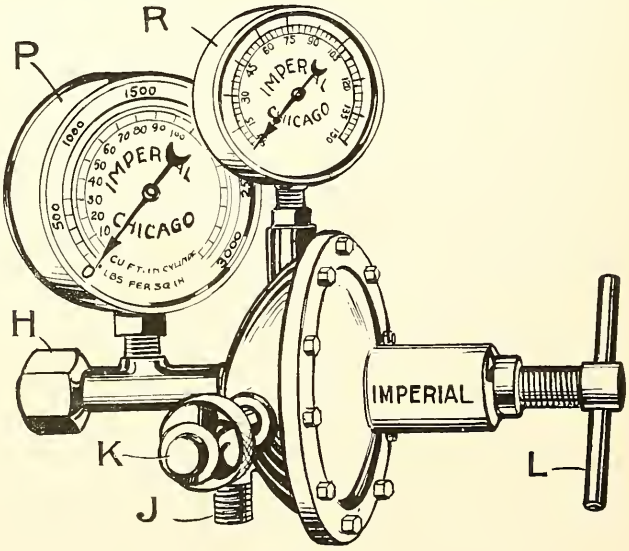


PLATE 4

Imperial Oxygen Regulator—Type C

H—Tank Coupling. J—Hose Connection. K—Outlet Valve to Hose. L—Regulating Screw. P—Tank Pressure Gauge showing pressure in tank and contents in cubic feet. R—Working Pressure Gauge showing pressure delivered to torch.

regulator then is to reduce the tank pressure to the amount required, to deliver an absolutely steady flow of gas at this pressure and to maintain the necessary volume, irrespective of the tank pressure. Imperial regulators will do all these things and keep doing them if they are properly treated.

Note carefully the explanation following and so avoid the troubles of those not understanding what an oxygen regulator is.

The principle of operation is very simple. After the regulator is attached to cylinder and the tank valve has been opened, the flexible metal diaphragm is interposed between the pressure of the cylinder and the heavy springs, the tension of which may be set at the pressure desired by means of the regulating screw. If, for instance, the pressure of the gas desired is twenty-five pounds, the regulating screw is turned to the right and the springs forced against the diaphragm to this tension, which will so register on the small gauge directly over the body of the regulator. As the gas enters the body of the regulator from the cylinder it passes through the seat and presses up against the diaphragm. It will quite readily be seen that whenever the pressure from the cylinder exceeds the spring tension, the gas pressing against the diaphragm will overcome the spring tension, thus forcing the diaphragm outward (against the springs) and as the plunger of valve is attached to the diaphragm, it is drawn against the seat of valve and the gas from the cylinder shut off.

The oxy-acetylene flame must at all times have a steady, even flow of gas. Therefore, the regulator, which is an instrument of very delicate manufacture, must be handled carefully by the operator to maintain this object.

Before turning on the gas at the cylinder, BE SURE THAT THE SPRING TENSION IS RELEASED, i. e., the regulating screw turned to the left, which brings the plunger of valve down onto the seat, thus closing the regulator. After opening the tank valve, turn the regulating screw to the right until the small gauge registers the pressure desired. NEVER TURN ON THE GAS AT CYLINDER WITH THE REGULATING SCREW TIGHT, AS THIS PUTS SPRING TENSION ON THE DIAPHRAGM and allows the gas from the cylinder to enter the body of the regulator very suddenly (because the plunger of valve is away from the seat) and as the sudden pressure strikes the diaphragm, the plunger is thrown violently against the seat, often causing the seat to become cracked or broken.

With the motor of an automobile racing, you wouldn't throw the

gears in mesh for high speed direct from neutral and attempt to start away from the curb—not if you want to keep your automobile very long—yet turning on the oxygen with the spring tension on the regulator has about the same effect on the regulator.

Bear in mind that the regulator is a steadying device—that the diaphragm is the balance between the high pressure of the cylinder gas and the spring tension and that at all times the movement of this diaphragm should be slow—never violent.

The low pressure gauge (R), Plate 4, is a positive index of regulator trouble. If you are operating, say at fifteen pounds, and after shutting off the valve on the torch, the hand on the dial keeps moving to twenty-five or thirty or forty pounds without stopping, it means that the seat is damaged—that the high pressure of the cylinder is leaking past the plunger of valve and the regulator should be immediately sent back to the factory for repairs. Only by violating some of the rules previously given would you be likely to damage this seat; but once damaged, it should be immediately repaired.

ACETYLENE—The acetylene cylinder usually has a broad base; and, therefore, is not so easily tipped over as the oxygen; yet, even in this instance, especially where the smaller tanks are used, it is advisable to have it clamped and the truck is therefore a desirable and a wise investment.

ACETYLENE DOUBLES IN PRESSURE AS THE TEMPERATURE IS DOUBLED—Therefore, keep the cylinder away from any excessively hot place. Do not carry this idea so far, however, as to keep the cylinder cold, as better and more economical welding results are secured with the cylinder in a WARM place; i. e., with a temperature of around 90° F. As the gas is used, and the pressure decreased, this temperature may be increased without danger, especially as in using the gas there is considerable refrigeration, which is offset by having the cylinder warm.

Remember, that besides the acetylene in the tank, there is also a very volatile liquid. When the gas in the tank is exhausted, CLOSE THE VALVE, as the vaporizing of the liquid and its escape might cause an explosive mixture.

DON'T USE AUTOMOBILE LIGHTING CYLINDERS EXCEPT IN EMERGENCY. They are much more expensive to operate than regular welding cylinders and in addition, the liquid absorbent in the cylinder is liable to be withdrawn, thereby lowering the heat of the welding flame and adversely affecting the weld. Acetylene

should not be used at a rate greater than one-seventh the tank capacity per hour. If a tip consumes 20 feet of acetylene per hour and the acetylene cylinder used is a 100-foot size, it will readily be seen that the rate of withdrawal of gas is much too rapid and a 225-foot size should be employed, or if small cylinders only are available, connect two or more by means of a manifold, attaching the regulator to the manifold, to insure getting the necessary volume of gas without drawing out the acetone.

LEAKS—Acetylene has a decided odor, quickly recognized even if the leak is a very small one. If such a leak cannot be located by the odor, it is advisable to hunt for it with soap suds, just as when looking for an oxygen leak. Should the acetylene ignite around the packing nut or between the regulator and the connection, do not be unnecessarily alarmed, as the flame will not go back into the tank. Simply blow it out and tighten the nut where the gas is escaping, if the leak is a small one. The chief danger to guard against is the continued escape of gas and its ignition when an explosive mixture is formed. Such a condition could only occur through extreme carelessness.

ACETYLENE REGULATOR—The principle of this regulator is the same as that used for oxygen, and while the initial pressure to be reduced is comparatively small, it is well to be governed by the same rules in its care as apply to the oxygen regulator.

It is equipped with two gauges, one 500 pounds to indicate tank pressure and one 50 pounds, showing the line or torch pressure. Note that the 500-pound gauge indicates tank PRESSURE, not CONTENTS. This pressure will vary according to temperature; and a cylinder having 150 pounds may have the same cubical contents as one having 300 pounds pressure. This is fully explained later in the chapter devoted to Figuring Costs, Page 43.

WELDING TORCH—The Imperial torch is so constructed that the factor of strength is considerably greater than in any other on the market—this for the reason that a welding torch is very often carelessly handled; if it receives very ordinary care, it is practically indestructible.

The oxygen hose is attached to the upper connection (marked O), the acetylene to the lower (marked A). Both are ground joints and

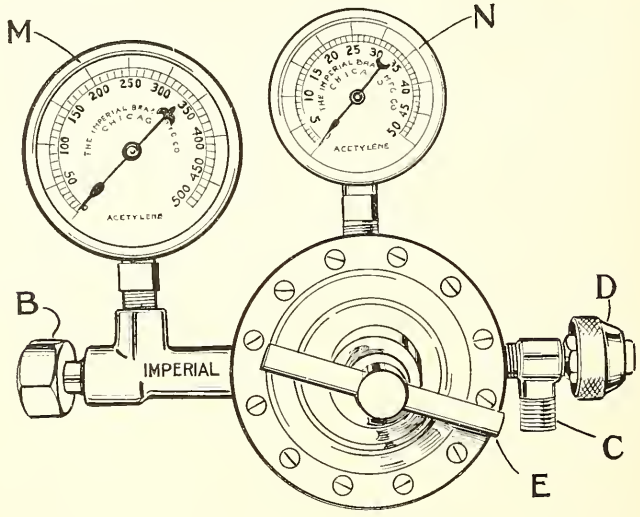


PLATE 5

Imperial Acetylene Regulator—Type AA

B—Tank Coupling. C—Hose Connection. D—Outlet Valve to Hose. E—Regulating Screw. M—Tank Pressure Gauge showing pressure in tank. N—Working Pressure Gauge showing pressure delivered to torch.

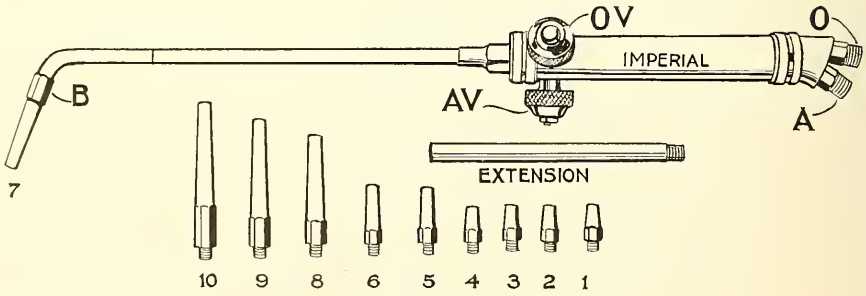


PLATE 6

Imperial Welding Torch—Type B

A—Acetylene Inlet. B—Removable Welding Tip. AV—Acetylene Valve. O—Oxygen Inlet. OV—Oxygen Valve. Nos. 1-10 are the Welding Tips.

make up easily. The shut-offs are so situated as to enable the operator to adjust the flame while welding, with the thumb or fore finger of the hand grasping the handle.

LEAKS—After attaching the hose, see that the connection is tight before lighting the torch. Make sure of this, as a leak at this point may burn the hand. Then see that the valves are tight and do not leak, either open or shut. After continued use, it may be found necessary to clean these small valves and to repack. Be careful not to use oil and for packing use graphite-asbestos.

ABUSE OF TORCH—Don't attempt to use the welding torch as a pair of tongs in helping to turn a casting while welding. Remember that it is constructed of bronze composition and is made to weld with—not for use as a crowbar.

In working on a hot casting, where there is little escape for the heat waves, except directly against the torch, keep it cool by having a bucket of water handy and SLOWLY immersing the torch, with the acetylene shut off and the OXYGEN PARTLY SHUT OFF. Proper judgment in this respect will prevent the burning of tips and the fouling of the mixing tube, due to heating the mixed gases to the ignition point.

FLASHBACK—Due to the long mixing chamber of the Imperial torch and the natural cooling effect of the gases under pressure, the flashback is an almost unknown occurrence. Bringing the tip in close contact with the metal will not (as it does in most welding torches) cause the Imperial to burn back to the mixing chamber.

There are only two ways in which a flashback will occur—both easily prevented by the operator, if he is careful.

The first is lack of acetylene—that is, giving the flame too lean a mixture. The adjustment of the gases is fully explained on Page 21. Since good welding can only be obtained with the correct flame, which is neutral in character, it behooves the operator to be careful in his adjustment and not allow the oxygen to be in excess of the acetylene, which would give a lean mixture and so invite a flashback.

The second is heat. A mixture of acetylene and oxygen will ignite at a comparatively low temperature. Therefore, if the torch is heated to a fairly high degree, the gases will burn back to the mixing chamber. This degree of heat may be obtained by holding the torch over a heavy, hot casting (previously described) or by bringing the torch in continued close proximity to the metal and causing a snapping; i. e., the TEMPORARY burning back of the gases. If this

snapping is continued, the tube or mixing chamber eventually becomes hot enough to ignite the mixed gases and a flashback results.

When a flashback occurs, shut off the oxygen first, then the acetylene and cool the torch. Then relight and adjust the flame, BUT the flashback may be almost entirely obviated by attention to the two reasons given. It is better to eliminate the CAUSE than to allow it to flashback, as the continued burning back of the gases may seriously affect the proper regulation of the torch.

BURNED TIPS—Welding in a corner, or in a depression, where there is no escape for the heat waves, except against the torch tip, may cause the tip to become heated to such an extent that it will melt. By a study of local conditions, we are usually able to plan to avoid this by proper manipulation of the torch. If we are not able to do this, cool the tip frequently, as a burned tip is not again usable.

RAGGED TIPS—By flying sparks or molten flux, the end of the tip at times becomes partially clogged and the flame then assumes a ragged shape. Clean these tips with soft wire or wood, using care not to get the aperture out of round.

CARE OF TIPS—Bear in mind that heat causes metals to expand—use care in screwing up or unscrewing the tips while they are hot, since carelessness in this respect may strip the thread. Keep the tips in a clean place, away from dirt—in the apparatus box or in a small rack near the welding table.

HOSE, GOGGLES, SUPPLIES—Examine the hose at intervals for leakage, especially where it clamps to the torch. Either gas leaking at this point may cause a serious burn. So far as possible, keep the hose off the floor away from oil and possible damage by being trampled upon. And while welding, see that it is in such a position that no one may trip over it, not especially because it will hurt the hose, but more for the reason that such an occurrence might mean a bad burn to the operator by pulling the torch from his hand.

It is always necessary to watch each detail of the molten metal—keep the welding glasses clean to enable you to do this properly. NEVER WELD WITHOUT THESE GLASSES, since to do so means an impairment of the vision.

Welding rods should be kept clean and in a place convenient to the operator; as they become short, weld them together in leisure time, to be ready when the job is started upon. Keep the flux cans closed when not in use—especially the aluminum, as this absorbs moisture from the air and is useless as a flux when this happens.

EXPANSION AND CONTRACTION

As we heat metal, we expand it; as it cools, it contracts. The degree of expansion is not the same with all metals, aluminum expanding and contracting more than cast iron for instance.

Different metals CONDUCT HEAT with varying degrees, copper having the greatest conductivity of the metals we have to deal with in welding, so we must take into consideration the expansion and conductivity of the metal we are welding in order that we may allow for the shrinkage when the metal cools. Since cold metal must occupy a smaller space than hot metal, it follows that unless we recognize this and plan to offset it in some way, this shrinkage is likely to distort the article we are welding or in some cases break it. NOTHING CAN PREVENT THE EXPANSION OF METALS WHEN HEATED OR CONTRACTION WHEN THEY COOL OFF AGAIN.

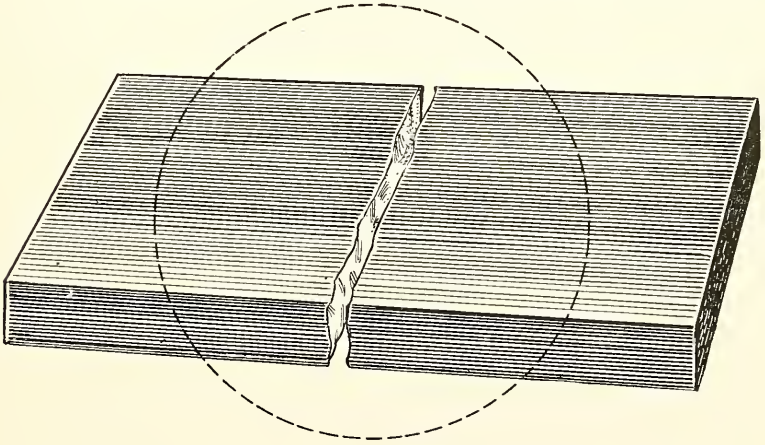


PLATE 7

The effect of expansion and contraction is illustrated in Plate 7. Suppose that we weld a bar at the break shown. As we heat it, the metal expands; but there is opportunity for it to expand on the ends, since they are free to move, or towards the break, and when the weld cools, the ends will move back or perhaps the bar will be slightly shorter—it depends upon how much care we have used in setting the job up.

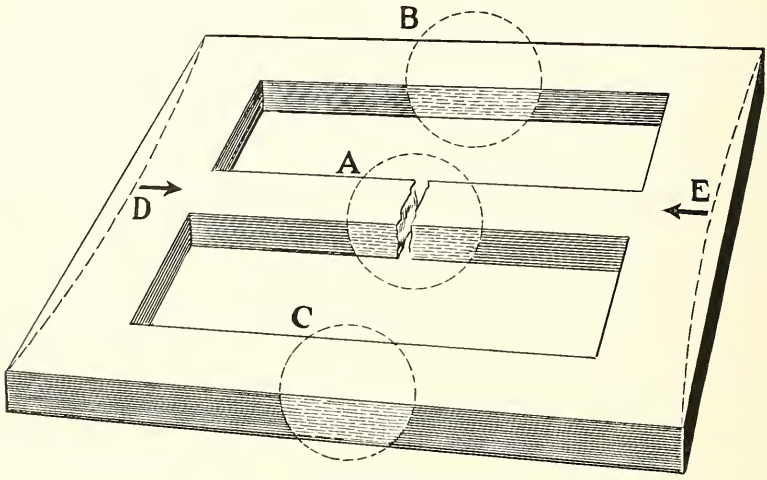


PLATE 8

Now, suppose that this bar is the middle member of a frame, as illustrated in Plate 8, with the same character of break. Here the ends are permanently attached and as we heat the bar at the break, the ends being rigidly held, have no opportunity to move and the expansion is all toward the break. Since cold metal must occupy a smaller space than hot metal, as the metal cools, the middle bar contracts and shortens and results in breaking the bar or some portion of the frame or the distortion of the frame in the general shape as shown by the dotted lines. Whether it breaks or bends depends upon the DUCTILITY of the metal, i. e., the ability of the metal to stretch. Wrought iron or steel, for instance, would probably bend out of shape. Cast iron would probably break. Aluminum might break or it might bend—it would depend upon the alloy used in the casting. But irrespective of whether the article is broken or bent, it would be considered an unsuccessful welding job, even though the weld itself is first class. It is, therefore, evident that this must be overcome in some manner before we can do successful welding.

The most common form is to heat the article all over in order to set up an equal expansion throughout and consequently have the metal cool equally all over. This is not possible in all cases, however, or practical. In the figure illustrated, it is not necessary, since we may heat the two side bars about as much as we would heat the middle bar in welding and thus take care of contraction, since in heating the side bars, the break in the middle bar would open up. Perhaps conditions are such that we are unable to heat either a portion of the article

or all of it. We may then use a jack to open the break in the middle bar a short distance, make the weld, and then slowly loosen the tension on the jack as the metal contracts. Or we may wrap wet cloths or wet asbestos or clay around the middle bar, close to the weld, make the weld and while making it keep cold water running on the material used—this method simply holds the expansion to a limited area and should be employed only when no other method is possible. Undoubtedly the better method in nearly all cases is the preheating of the article or a portion of it, though in each case proper judgment must be exercised.

The fact to bear strongly in mind and to understand thoroughly before proceeding to actual welding is, that expansion and contraction must always take place and that we cannot prevent it with jigs, vises, shafts or angle irons. We may offset its ill effects by one of the methods outlined in the preceding paragraph and we will do well to thoroughly digest this, since most failures in welding may be traced directly to lack of knowledge of expansion and contraction.

CHEMICAL ACTION OF THE FLAME

Metals are susceptible to certain chemical actions, especially under the influence of heat. Particularly, they have a high affinity for oxygen; that is, oxygen, either from the flame, from the air, or from wet gas, may unite with the metal and form an oxide. This oxide is detrimental to the weld, exactly the same as iron rust, which is one form of iron oxide, weakens iron; hence we must guard against oxidation.

Since acetylene is rich in carbon and the presence of carbon in steel or iron makes them hard and brittle, the flame must be properly adjusted to prevent an excess of carbon being deposited in the weld; in other words, to prevent carbonization.

Oxygen also has an affinity for the carbon in iron and steel and the loss of it changes the character of the metal. This action, however, is so like oxidation that we may consider it practically the same in guarding against it.

MECHANICAL EFFECT OF THE FLAME

Case hardened or tempered steel cease to be hard after being melted, as happens when a bond is made with the oxy-acetylene flame. In the welding of brass or bronze, we may melt out some of the alloy, changing the color and composition of the casting in the line of welding. Copper may lose its ductility—cast iron become brittle. To a

large extent we may prevent many of these detrimental chemical and mechanical changes by proper selection and use of the welding rods and fluxes, plus proper use of the torch and careful heating and cooling.

PREHEATING AGENCIES

Since it is often necessary to preheat an article, either in sections or all over, to prevent breakage or distortion and in some instances also to prevent detrimental chemical actions, we must decide upon an agency to do this.

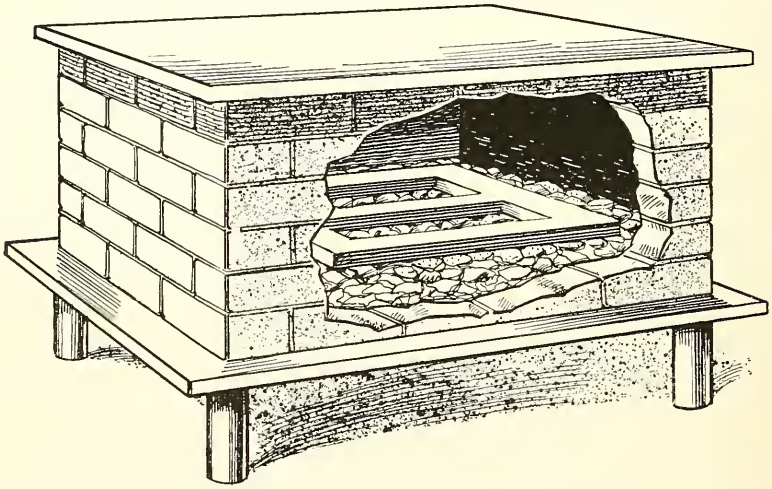


PLATE 9

The simplest form of preheating is undoubtedly a temporary fire brick furnace, with charcoal, as shown in Plate 9. But we may also use gas to decided advantage, if we are properly equipped with a blower to furnish air for it, or we may use kerosene oil.

The choice of a preheating agency must be governed entirely by our needs. Any of the three methods are usable, but for reasons which are obvious, the oil or gas torch offers at times many advantages over charcoal, i. e., the ability to concentrate the flame when it is advisable to do so, as when only a section of a casting requires preheating, for example. We may also use charcoal in a hearth which we may construct ourselves, similar to Plate 10, covering the article with asbestos paper while heating and welding.

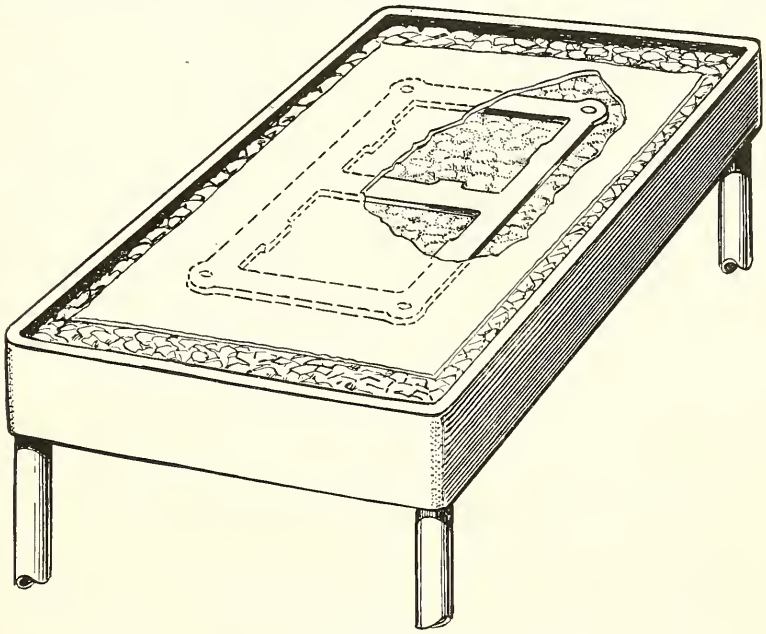


PLATE 10

SLOW COOLING

Care must also be exercised in cooling slowly to effect a uniform distribution of the heat in order to prevent breaks or strains and also for one other important reason later more fully described under Cast Iron. Sometimes we are able to use the preheating furnace for cooling, allowing the article welded to cool with the dying fire; but a box

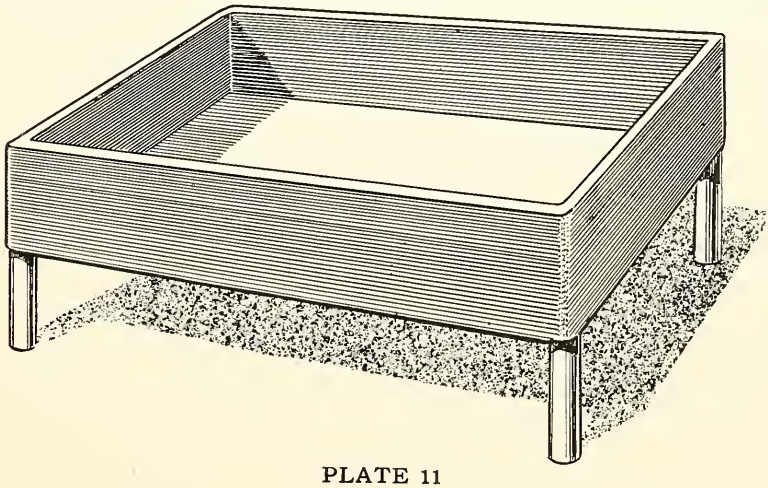


PLATE 11

made of sheet iron, with seams welded, similar to Plate 11, and filled with a good non-conductor, such as asbestos, mica, or even ashes, costs little to make and the hot casting may be placed in it to insure even cooling, away from draughts.

WELDING TABLES

For welding small pieces or as an aid in securing the proper alignment of articles with flat surfaces, a table with a heavy cast iron top is indispensable. Such a table may be purchased from the Imperial Brass Mfg. Co. In addition to this, we should have a table with a fire brick top, the size of which will depend upon the kind of work handled, but which should be large enough to construct upon it temporary heating furnaces if we so desire. Such a table may be made from pipe, angle or channel iron, with all connections welded, as in Plate 12.

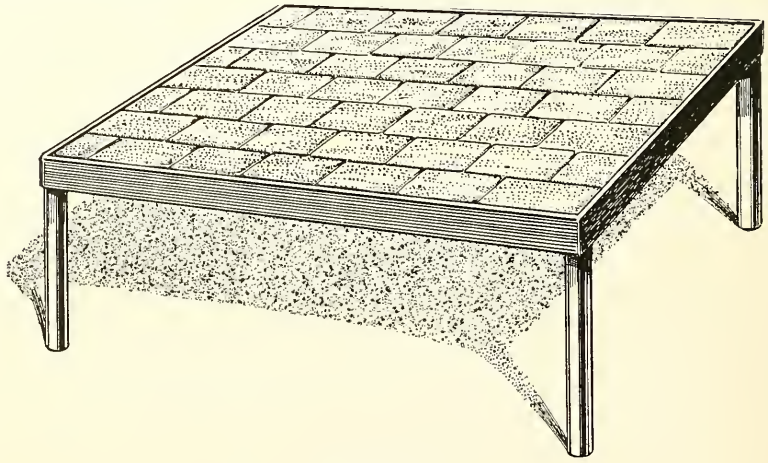


PLATE 12

CLAMPING DEVICES—TOOLS

No specific advice can be given regarding shop equipment, as this will depend wholly upon the character of work to be welded. In some instances, we need nothing but the welding outfit. In others, we should have clamps to aid us in securing alignment, V blocks for the same reason in shaft welding, etc.

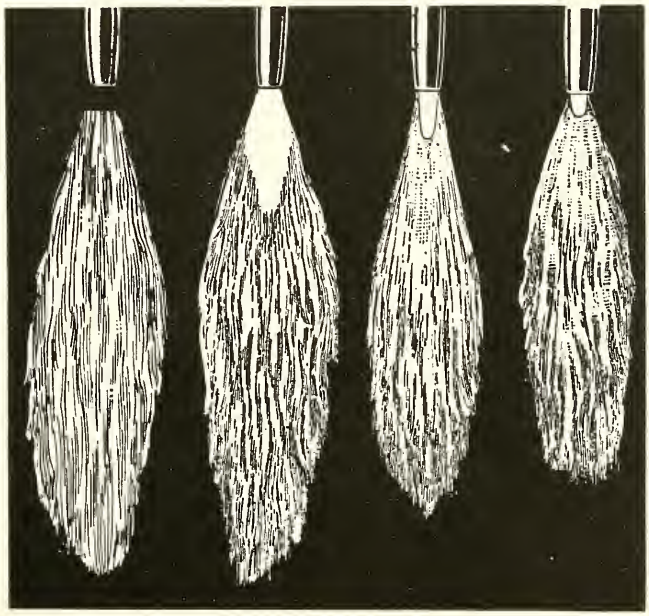
A stationary grinder is a necessity both in preparing and finishing castings and a portable grinder may be classed as desirable in most cases but not essential.

Asbestos paper, purchased cheaply by the roll, should always be on hand to shelter the castings from draughts while heating and also to protect the operator from intense heat radiation.

Hammers, chisels, files, tongs, etc., are inexpensive but necessary aids.

REGULATION OF THE FLAME

A B C D



A B C D

PLATE 13

A—Acetylene turned on with sufficient pressure, so that it blows away from the tip. This space depends upon the size of tip being used. On the No. 1 the interval between tip and acetylene flame would be about $\frac{1}{16}$; on the No. 10, $\frac{1}{4}$ of an inch.

B—Oxygen partly turned on, united with the acetylene. The flame has begun to assume two different shapes and two different colors. The center flame is white and is shaped somewhat like a rosebud. Not enough oxygen has yet been given the acetylene and the flame is called carbonizing.

C—This is the neutral welding flame. The rosebud cone of the upper figure has become blunt, with no ragged edges and of a beautiful blue-white color.

D—An oxidizing flame—ruinous to welding. This is obtained by turning on too much oxygen and the cone has become shorter, of a darker, dirtier blue, and is more pointed. This view is exaggerated. The utmost care is necessary to guard against this flame, as even a slight excess of oxygen is detrimental.

Imperial welding tips are marked on the flat sides with letters and numbers to indicate size of tips and pressure required in pounds

and kind of gas. For example: Welding Tip No. 1 has on one side the figure (1), referring to size. On the next side is (A-2), which means a pressure of 2 lbs. of acetylene is required, and on the next side is (O-3), showing that 3 lbs. of oxygen are required, etc.

The pressures to use on each tip, as explained above, are meant for the guidance of the operator. Conditions beyond the control of the manufacturer, such as the possible clogging or partial clogging of one or both of the gas lines, the slight derangement of the indicating gauge, etc., prohibit at times an exact compliance with these pressures. Since the adjustment of the flame is of the utmost importance in successful welding, we must learn the various forms the flame is known to take, so as to familiarize ourselves with the correct one by observing its shape.

In Plate 13 are four views of flames which we should earnestly study. Particularly watch at all times the character of the flame, remembering that even though adjusted properly at the START of welding, various conditions—expansion of the gases by the heat arising from the weld, refrigeration of the gas caused by its release from pressure, enlargement or decrease in the sizes of the orifices by heat or dirt—tend to change the character of the flame DURING welding. With only one flame—the neutral—are we able to successfully weld. During the weld, then, we should find out if the flame is neutral by slightly opening the acetylene valve (or increasing the pressure on the acetylene by means of the diaphragm valve regulating screw) until the cone begins to assume the ragged shape shown in Plate 13-B (carbonizing).

We may, without particular harm, set the pressure on the regulating valves, say at ten pounds each, and adjust the flame by means of the valve on the torch, if we are using tips up to the No. 7 size. For the larger sizes, it will be better if we adjust the flame at the regulators.

It will be noted there are two distinct shapes to the welding flame, the inner, short, very brilliant, and the other, long and of faint luminosity. We call the inner the CONE and the outer the ENVELOPE. We will frequently refer to the CONE in our text; let us understand, then, that it is the short, brilliant flame shown at "C," Plate 13.

BEVELING OR CHAMPFERING

Since oxygen-acetylene welding is the joining of metals by fusion only and without hammering, it is necessary to bevel each edge of the

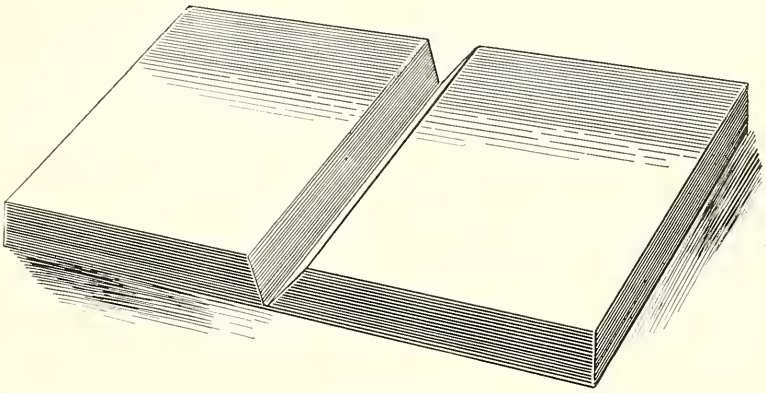


PLATE 14

break on an angle of about 45 degrees, as in Plate 14, so that the heat of the welding cone is sufficient in all places to flow the metal together. On very thin sections, this beveling is not necessary, but the beginner should not attempt the welding of anything over one-eighth inch without first grinding the edges on about the angle stated. On heavy work, where it is possible to do so, this beveling or champ-

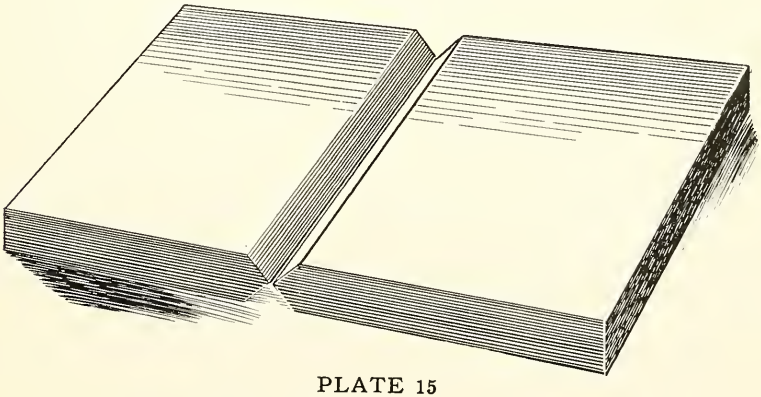


PLATE 15

fering should be done from each side, as in Plate 15. To do this, we may use the grinder, a hammer and chisel, possibly the drill press with a proper shape of drill, and in the case of wrought iron or steel over a quarter inch thick, the cutting torch. If this is done, it is well to thoroughly clean the edges to be welded, as well as a space each side of the weld, varying with the thickness of the casting, but ranging from one to three inches, to eliminate any possibility of dirt, including rust, from an outside source entering the line of welding.

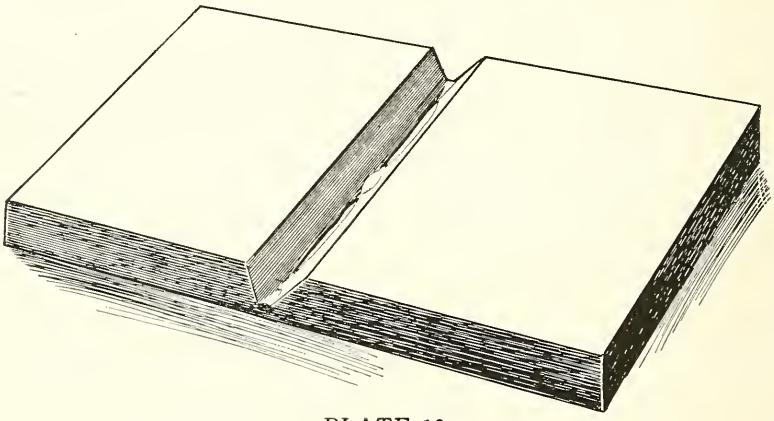


PLATE 16

Many times the shape of the article does not permit us to make this bevel all the way without danger of losing the alignment of the pieces. In a case like this, leave two or three places on the bottom of the casting to permit setting up, which is more clearly outlined in Plate 16.

Beveling is very important; unless we appreciate the necessity of doing it, good welding becomes extremely difficult and even very experienced operators will execute bad welds.

HOW TO HOLD THE WELDING TORCH

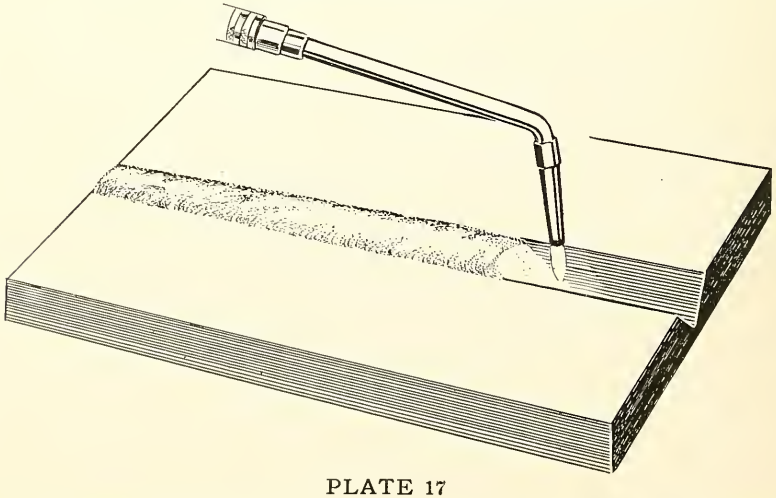


PLATE 17

Theoretically, the proper way is to hold the torch as illustrated in Plate 17, so that the flame is directed in the line of welding, with

the work progressing AWAY from the operator. This method undoubtedly is the most economical, since the ENVELOPE of the flame preheats the section to be welded and a weld made in this manner takes advantage of this preheating, which costs nothing. As we become expert, and where conditions permit it, this is the proper way to execute the weld. For the beginner, however, it is rather dangerous, since there is every likelihood of flowing the metal from the welding rod ON TO the line of welding, without getting it in fusion with it.

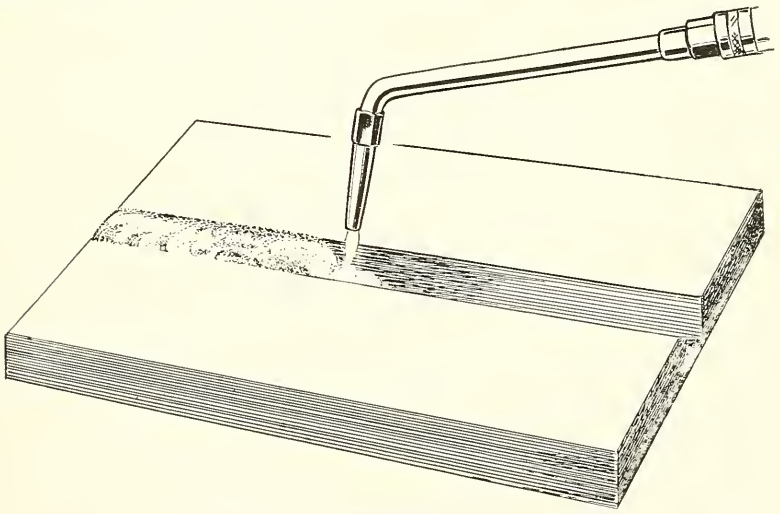


PLATE 18

Another method recommended by some is directly opposite to this idea, as in Plate 18. Here we work in the same direction as the line of welding, but our flame is pointing TOWARD the area already welded. In this manner there is much less chance of not properly fusing the metal, but this method not only does not take advantage of the preheating effect of the envelope, but keeps the cone on the welded section after it is welded, which is a serious objection. With all metals, we want to properly fuse the particular section we are working upon, but once fused, we must move on to the next spot immediately to prevent oxidation or burning of the material.

Both of the above methods have a very serious disadvantage when working upon hot, heavy material, inasmuch as the channel made by beveling offers a pathway for the sweep of intensely hot waves and the position of the operator in these two methods places his hands and face directly over this channel. There is considerable discomfort in

some cases, even though the article is protected by asbestos paper; and since we cannot do proper welding unless we are watching the weld carefully, it seems to us that the best manner of holding the torch is as follows:

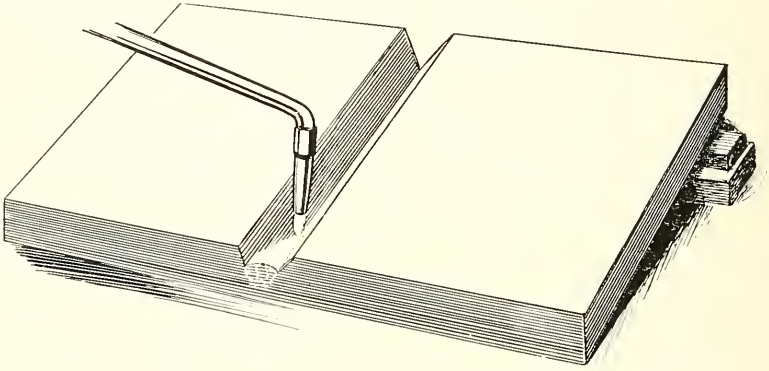


PLATE 19

Note carefully Plate 19. Here we are working at right angles with the line of welding, with the flame on an angle, pointing away from the line of welding. To prevent flowing hot metal ON TO comparatively cold metal, we would advise that the article welded be slightly raised on one end, so that the operator is always welding slightly UP HILL. Note carefully the angle of the HEAD of the torch in relation to the angle of the break or the sides of the metal being bonded. The torch is held so that the flame strikes BOTH edges at once. We may quite easily arrange the height of the welding table or the position of the casting to effect this position without discomfort. MAKE CERTAIN THAT THE FLAME DOES STRIKE BOTH EDGES, since failure to do this means that the material from the welding rod is brought into fusion only with one side and merely sticks, without welding, to the other.

CHOICE OF PROPER SIZE TIPS

Thickness of Metal.....	1/32"	1/16"	3/32"	1/8"	1/4"	3/8"	1/2"	5/8"	3/4"	1" and over
Size of Tip to Use.....	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10

Above will be found a table giving approximately the size tip to use on mild steel plate of a given thickness. It will be understood that this table cannot be exact, but is meant as a help to the

beginner. It is made up on the basis of welding without preheating and it will help us in arriving at a decision as to ABOUT which size to use. As we become more skilled, we may use a slightly larger tip than we do when learning to weld, and this results in faster welding, with a consequent saving of gas, since there is less radiation of heat, i. e., we bring the weld into fusion and get away quicker with a large tip than we do with a small one and there is less lost heat, due to the conductivity of the metal. More will be said about the choice of tips under the various Metal subjects. Let us carefully read the different subjects, whether or not we are interested in the actual welding of the metal covered, since the same GENERAL ideas of cast iron welding, for instance, would apply to other metals and we will save ourselves considerable trouble by mastering the principles of welding by a little study first, and afterwards some practice.

CAST IRON

The welding of cast iron with the oxy-acetylene flame is comparatively easy, if attention is paid to the simple rules, which to a large extent, have already been outlined.

The cast iron in common use is known as "grey;" it is quite soft, easily machined and has a lower melting point than wrought iron or steel. It contains two kinds of carbon, combined and graphitic. If we change the graphitic into combined, we have white cast iron, extremely hard, very brittle and practically impossible to machine. Because of certain chemical actions which take place when cast iron is melted, we may obtain a very brittle weld in this manner unless we pay strict attention to ALL of the following requirements:

Heat or cool slowly.
Use a proper welding rod.
Employ a good flux.
Handle the torch carefully.

We have already learned the value of preheating to overcome the ill effects of expansion and contraction. Preheating is also an economical factor, since oxygen and acetylene are more costly than ordinary means of heating, and with cast iron it is essential that it be carefully heated and as carefully cooled to prevent hardening.

The casting to be welded should be beveled as previously described. If entirely broken through and the ends are free to move, we should slightly separate THE EDGES before we start welding to allow for contraction. This separation, if we have properly champ-

fered the break, will be quite short—about 1/32d of an inch will be found about correct.

The utmost care should be exercised in preparation and in setting the article up to prevent its moving while it is being welded. Since we have a comparatively light edge from beveling, it is advisable to flow the metal together at this spot, "Tacking" it, as it is called in the welding shop.

Especial care should be used to heat slowly, remembering that in the construction often employed, we will find heavy sections adjoining light and the heavy section requires more heat than the light. Whatever means we may employ to preheat then, arrange to have the casting heated evenly and this can only be done by heating slowly.

The size of the welding tip will be about the same as we would use for the same thickness of steel. While cast iron melts at a lower temperature than steel, its ability to absorb heat is slightly greater than steel and this will offset the lower melting point.

The welding rod is furnished in three sizes; we will choose for the one best adapted to the work that size which is somewhere near the same thickness of the metal—up to one-half inch in thickness. Beyond this thickness, we will use a rod of about 5/8ths and on extreme thicknesses we may tack two or three together, though this is rarely necessary.

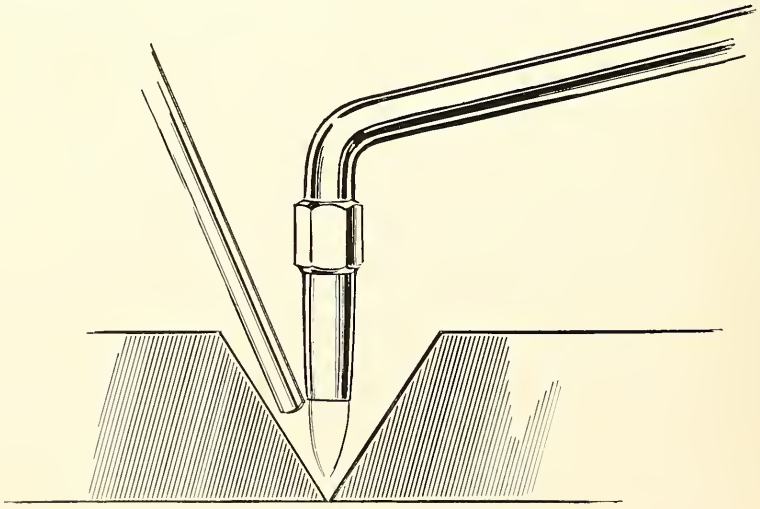
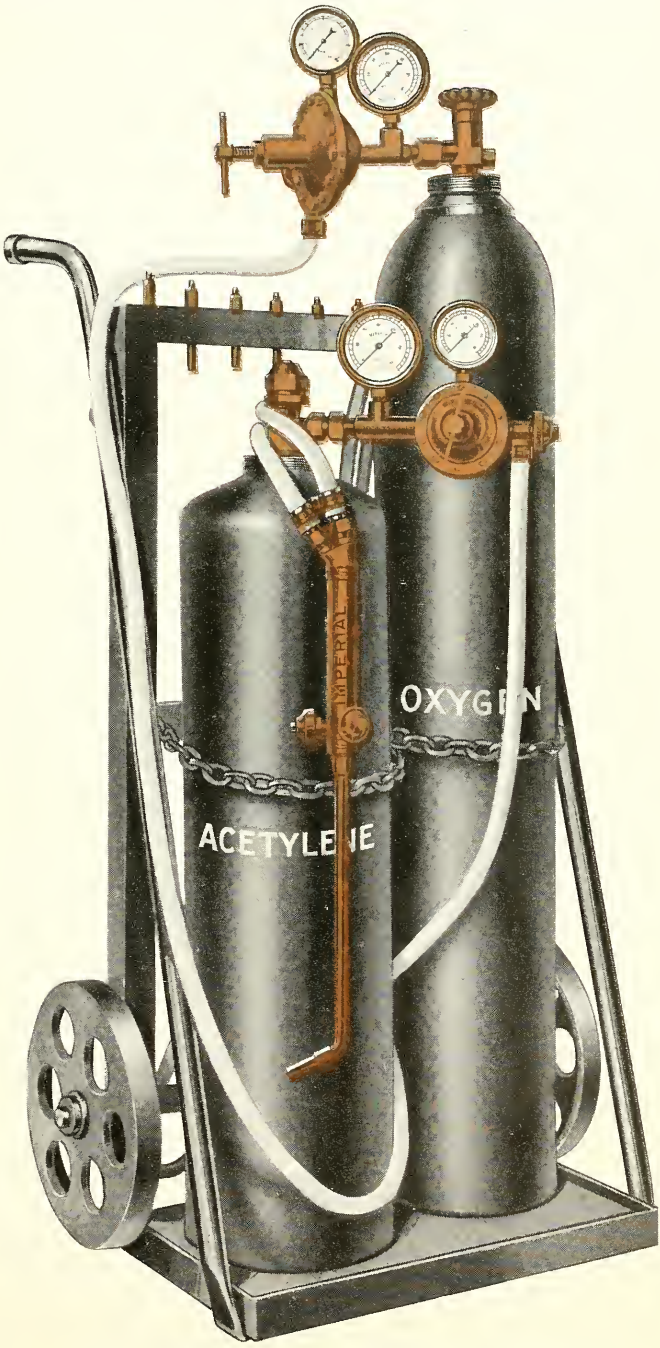


PLATE 20

Now, with the welding rod in one hand and the torch, with the

Imperial Oxy-Acetylene Equipment



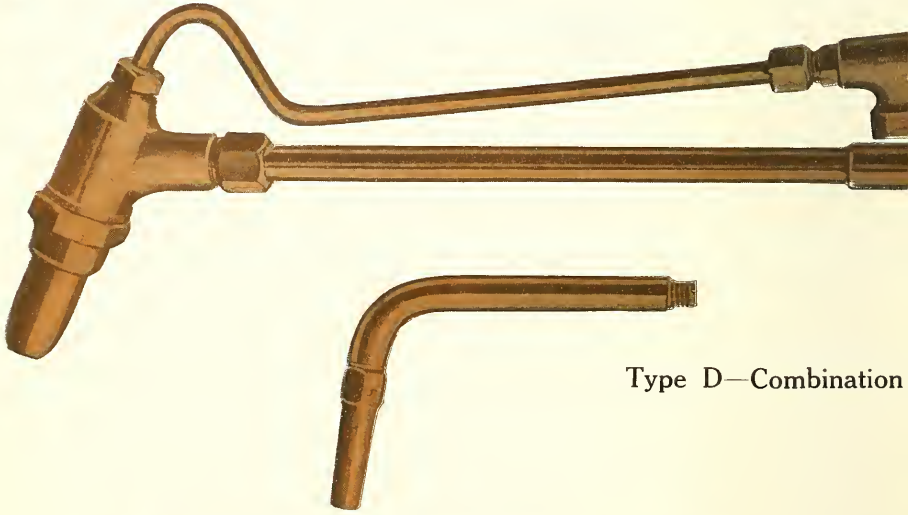
No. 1 Imperial Welding Outfit with Truck

NOTE—See catalog for full description and listing

IMPERIAL WELDING A

PATEN

Type B—V



Type D—Combination

Type E-

NOTE—See catalog

D CUTTING TORCHES

ENDING

ling Torch

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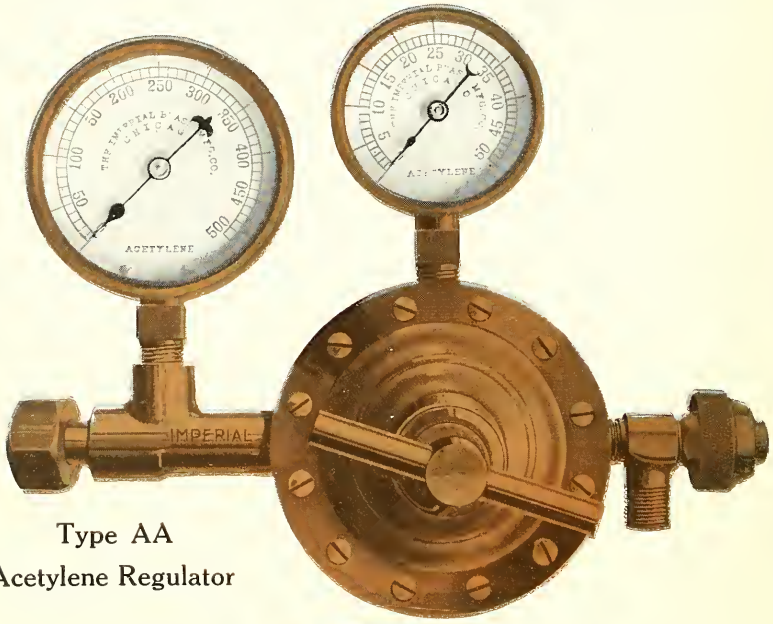
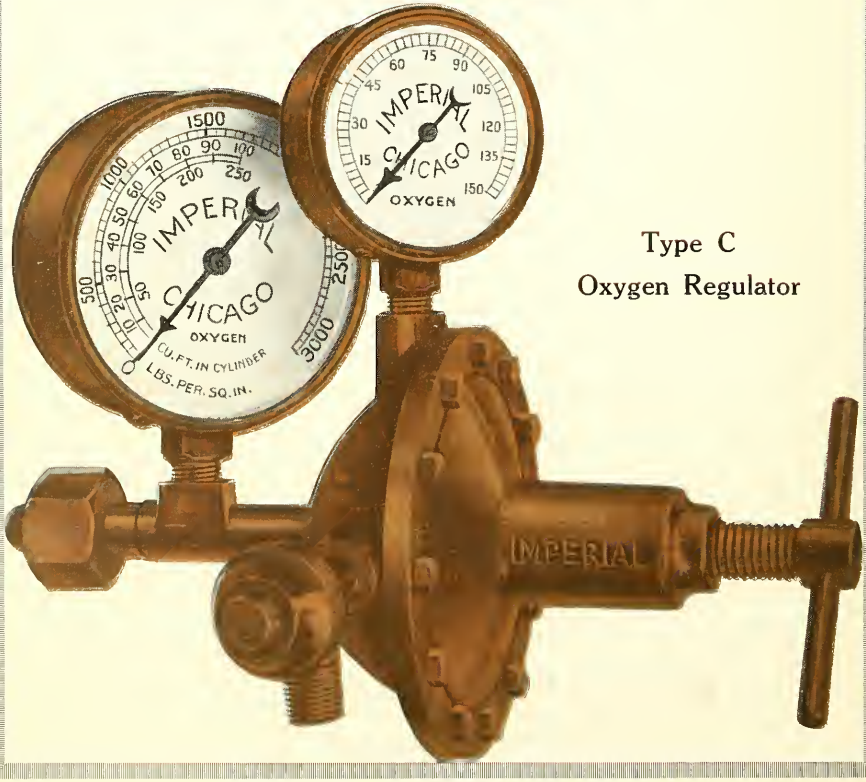
tting Torch

Imperial Oxy-Acetylene Regulators



Type AA
Acetylene Regulator



Type C
Oxygen Regulator

NOTE—See catalog for full description and listing

flame properly adjusted in the other, and the flux can in convenient reach, we are ready to start welding. Presumably the casting is at a red heat in the furnace and we may protect ourselves from any excessive heat by using the asbestos paper to cover such portions of it as may be necessary.

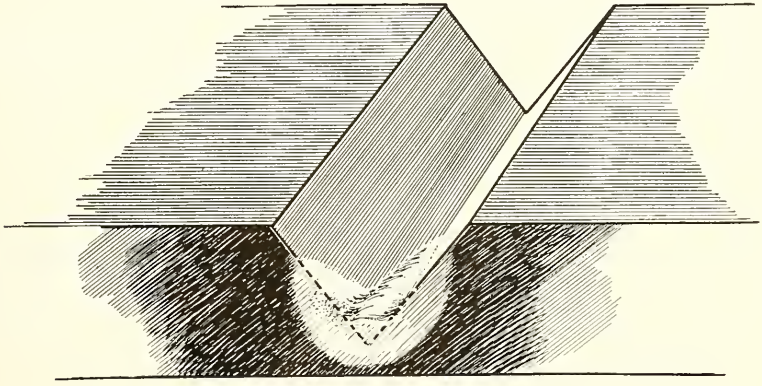


PLATE 21

Bring the welding flame down to the metal until the end of the cone is almost, but not quite, touching the edges, as in Plate 20. The welding rod is placed near the flame to slightly heat it—then it is dipped in the flux can and the flux picked up by the hot rod is placed in the spot the flame is playing upon. Usually this is sufficient to break the film of oxide and to cause the metal to flow together. Note that we have added no material from the welding rod as YET. Now, we melt the SIDES of the break and flow them towards the bottom, until the weld has the general appearance of Figure 21. Then we are ready to use the material from the welding rod, which should be kept in contact with the weld at all times to avoid loss of heat. REMEMBER THAT THE ARTICLE AND THE WELDING ROD ARE THE SAME METALS, MELTING AT THE SAME TEMPERATURE. We must, then, keep the article and the rod in fusion at all times to effect a bond. Be very careful that the metal is actually melting while the rod is being added.

Avoid the habit of pulling the torch away from the weld—rather use a slow circular movement which insures fusion and does away with loss of heat. Use the flux sparingly—never throwing it in with the hands—the amount picked up by the hot welding rod is sufficient at all times. At times it may be necessary to break the oxide by

stirring the molten iron with the rod and if the metal is very dirty, by pulling it out of the line of welding by means of the rod.

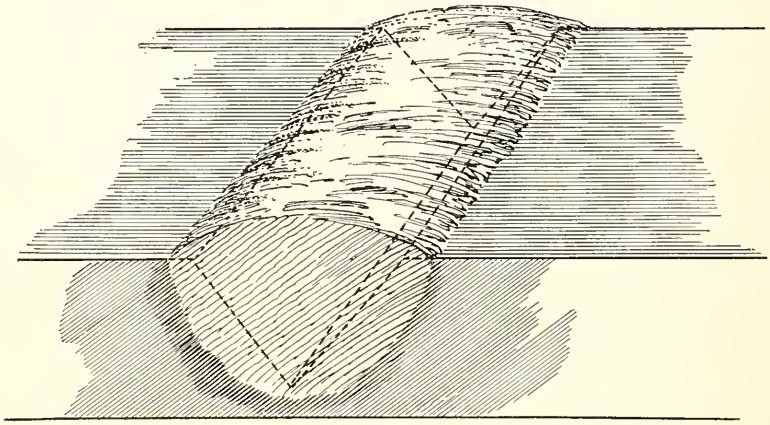


PLATE 22

Do not move away from the section being worked upon until the weld on that section is complete, as is shown in Plate 22. Never reweld without first grinding out the old material. Don't bring the cone in direct contact with the metal—hold it just a little distance away.

As we progress with the welding, we note that the metal always does not flow where we want it to; i. e., where we are holding the flame. The force of the flame usually prevents this and we add the metal from the welding rod at a point a little distance away from where we actually want it to flow, and when we are ready to have it join the casting, we remove the flame from that point and swing the metal to the section desired by the circular motion described.

Cast iron does not immediately solidify the moment the flame is removed—it remains liquid for some little time and this condition presents two difficulties; one the danger of allowing this fluid metal to flow over, without bonding to other metal, and the other the collapsing of the weld. The first difficulty may be offset by watching the weld carefully and bringing all parts into fusion. The second one is usually experienced by beginners and is caused by their lack of knowledge of the metal and the force of the flame with the metal in a liquid condition is sufficient to cause the metal to collapse and create a hole. When we get this condition, it is sometimes discouraging, as our efforts to fill up the hole usually result in making it larger.

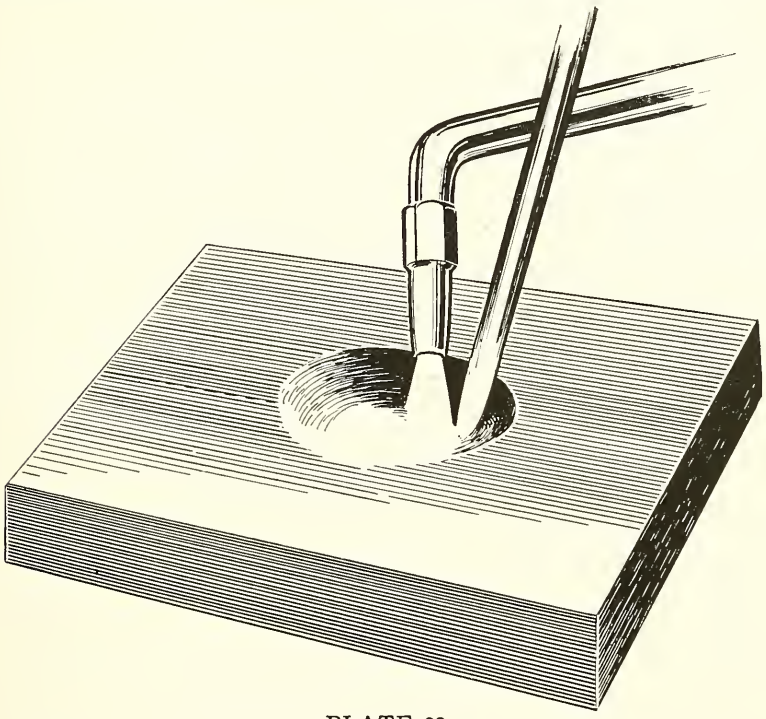


PLATE 23

Remember that one of the reasons for the collapse is the force or velocity of the flame—the metal is fluid all the way through and this force is sufficient to let it drop. We must, therefore, have a solid base at all times, which may be secured by the circular motion of the welding torch—not keeping the flame in one spot too long. To fill a hole, work down the sides the same as we have done in starting the weld, then tip the torch on an angle as illustrated in Plate 23, being careful, however, to keep the metal in fusion all the time. The idea is, as may readily be seen, to divert the direction of the force of the flame. This same method is applicable where small sections may be missing.

Where large sections are gone, we may make a rough pattern by the use of plaster paris and cast the desired design, or from useless castings of approximately the same thickness, break several pieces and by properly tacking them, form the general shape required. The user of the oxy-acetylene torch should realize that he has at his command a very powerful agent capable of replacing missing parts—a true "putting on" tool.

If we have carefully followed out the directions given for cast iron welding, we have a joint which is even stronger than the original article, and we can make it considerable stronger by adding additional metal to the line of welding, as we may desire, to strongly reinforce it. If we have had trouble, if the metal is hard, or if we get contraction cracks, it is because we have not properly heeded the suggestions given.

Since the welding of cast iron is usually repair work, the welder does not have a choice of conditions. He must take the article as it is, study carefully its construction with a view of determining the effects of expansion and contraction and plan to overcome them; he must use a welding rod which will prevent hardness; a flux which will make the metal fluid and remove the oxide; and use judgment in slow and careful cooling. These are not difficult conditions—they simply call for that judgment which is sometimes called a knack. A little study means a good weld—the lack of knowledge means a failure, and since foresight is a great deal more valuable than second guesses, let us understand these conditions so we may intelligently use the welding torch.

MALLEABLE CAST IRON

This metal is originally white cast iron, very brittle and hard. By heat treatment, the carbon content is changed, and instead of the brittle casting, it becomes ductile, fairly soft and changes to a darker color. Just how far into the body of the metal this change penetrates depends upon the size of the casting and the length of the heat treatment, so that a malleable casting, as it is generally called, may be steel on the surface, a semi-steel part way through and white cast iron at the core—better outlined in Plate 24.

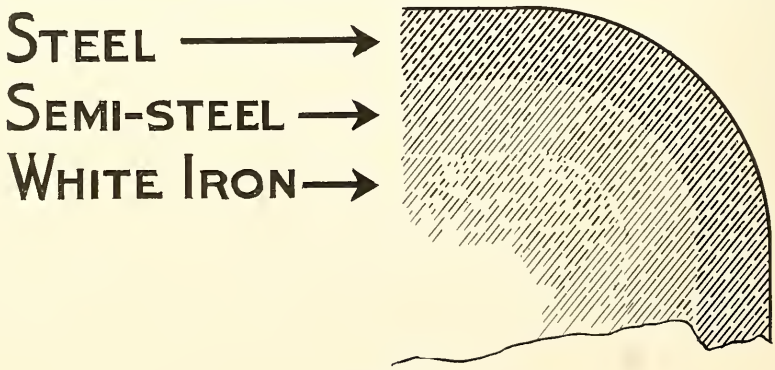


PLATE 24

Very small castings sometimes are steel all the way through and we may weld them without flux, using Norway iron or mild steel as the welding rod.

In nearly all cases, however, it will be found that the casting is composed of different metals—if the break is examined, we can tell this by the different colors. It is obvious that such a casting cannot be welded, since it would be extremely difficult to determine just where one metal left off and another began. The practice of using cast iron as a welding rod on malleable castings is not a good one, since the bond is very brittle and in all cases where strength is desired we will better use manganese or Tobin bronze—in this way securing a brazed joint instead of a welded one, of a different color than the casting but with the factor of strength a big one.

The break is prepared exactly the same as for any welding job, cleanliness in this instance being especially desirable, since the metal is not to be melted. Allowance should be made for the effects of expansion and contraction; malleable iron is less liable to break than cast iron, since it is ductile, but will be distorted unless such provisions are made. Use for a flux the same powder that is used for brass.

As with cast iron, do not let the end of the cone touch the casting, but hold it just a little distance away. Watch the metal carefully and when the spot the flame is playing upon reaches a bright red heat, bring the bronze welding rod, which has previously picked up some flux, down upon this section, being careful that the cone does not come directly in contact with the bronze rod. Bronze melts at a lower temperature than malleable iron and with the iron at a bright red heat, and with plenty of flux used, it will be found that the bronze attaches itself to the iron. We must not, however, MELT any portion of the malleable iron and we must not play the cone directly on the iron or on the bronze.

STEEL AND IRON

There are many different varieties of steel, but from a welding standpoint they may be classified by their carbon content. Those having a high carbon content are called hard steels; those with a low carbon content, soft steels. Wrought iron may be treated the same as mild or soft steel. To be sure, there are various alloys, such as vanadium, tungsten, nickel, manganese, chromium, etc., but in general these alloys will not seriously bother us, except in special instances and we will not take them into consideration, but will keep in mind whether the steel is soft, medium or hard.

Soft or mild steel is in the widest use. More than any other

metal, the welder will have to study it, since from previous understanding or training he has learned that it is the easiest metal to weld; whereas, it is by all means the most difficult and frequent failures result if the operator lacks certain elementary knowledge of it.

Mild steel is very ductile—it may be hammered cold or hot without fracture, and this fact is an invitation to the careless workman to disregard the effects of expansion and contraction.

We should bear in mind, then, that while it may not break, it will bend or distort, unless we take into consideration expansion and contraction, and we are very likely to have failures or leave a strain in the weld or in some section of the article welded, which will break while in use. Since the metal is ductile, it is not necessary at all times to preheat it in order to offset expansion and contraction—we may bend certain sections before welding, with a view of having the contraction straighten them and thus allow for contraction; we may use water or wet asbestos, clay, etc., to LIMIT the expansion—these methods are sometimes essential, where we cannot preheat, due to size or location of the weld, but in all cases where we may do so, the proper way is to preheat. Where we cannot do so, we will choose one of the other methods, but ALWAYS we must allow for expansion and contraction.

Previously we have spoken of the danger of oxidation and decarbonization. The oxidation, or we might say burning, of steel is very rapid, if we in any way neglect essential requirements, chiefly the proper adjustment of the torch to secure a neutral welding flame, a welding rod without injurious elements and the proper handling of the torch. Decarbonization is caused in the steels but not particularly mild steel, if we are reasonably careful. But particular care must be taken to adjust the welding flame to secure a neutral flame and to keep it neutral during the welding. Make sure you understand this.

PREPARATION OF THE WELD

Particular care must be taken in beveling steel to see that the V is especially wide. We are not able to burn out this V with the torch, as we are sometimes able in other metals, since to do so means severe oxidation or burning. On metal under one-eighth inch no beveling is necessary.

The proper preparation will depend largely on whether we are constructing or repairing. If we are welding new sheet metal, for instance, we may butt the edges and make what is termed a "flash" weld, using no welding rod. Such a weld will naturally not be as strong as the material, since it will not be as thick.

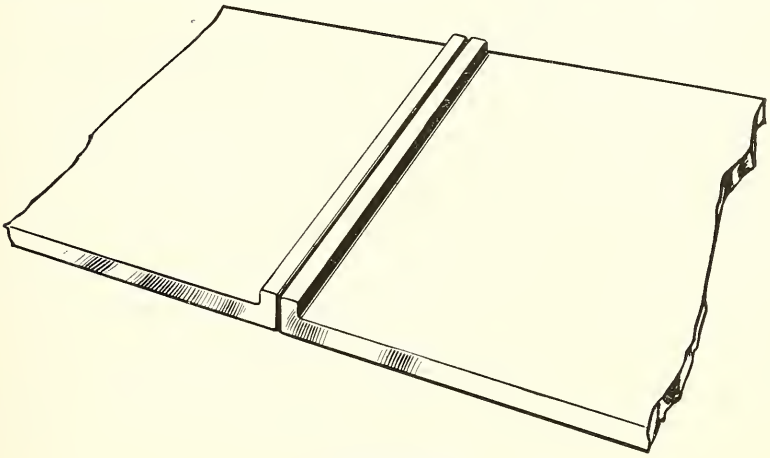


PLATE 25

Or we may upset the edges, as shown in Plate 25, and these upset edges take the place of the welding rod and melt down, as shown in Plate 26.

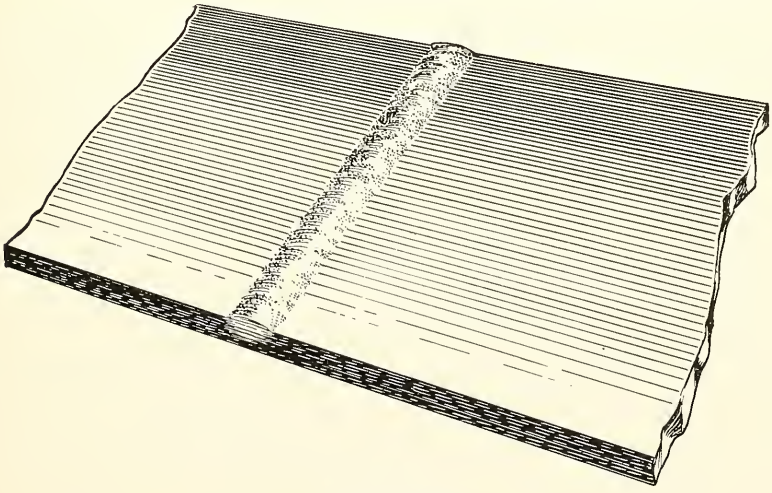


PLATE 26

As the metal becomes thicker, this is impractical, and we then bevel and use a welding rod approximately of the same material as the metal welded, being sure it is of the right quality, however.

No flux is necessary on mild steel and torch should be held in the position previously described, particular care being given to the necessity of having the flame directed to BOTH edges of the material.

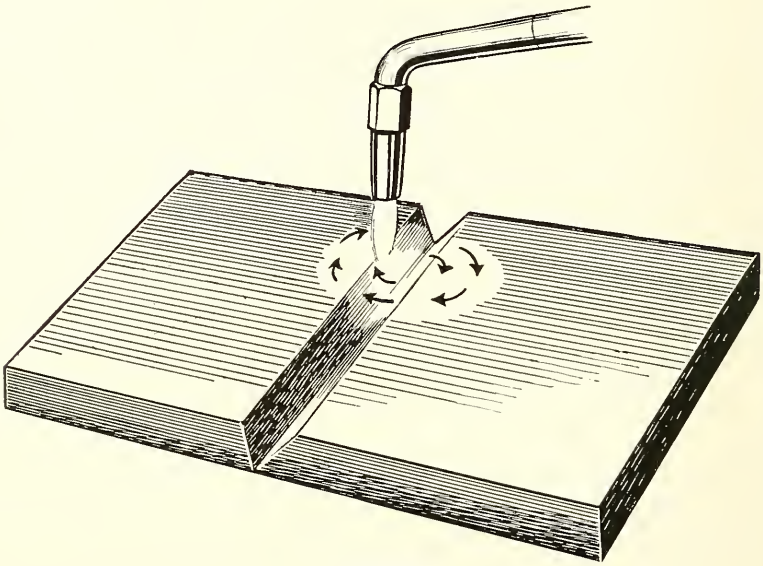


PLATE 27

Much of the mild steel welding done is impractical or impossible to preheat, and a frequent mistake of the beginner is to too quickly try and start fusion. To avoid this, we first play the torch in a gradually decreasing circle, as shown in Plate 27, with the end of the cone just

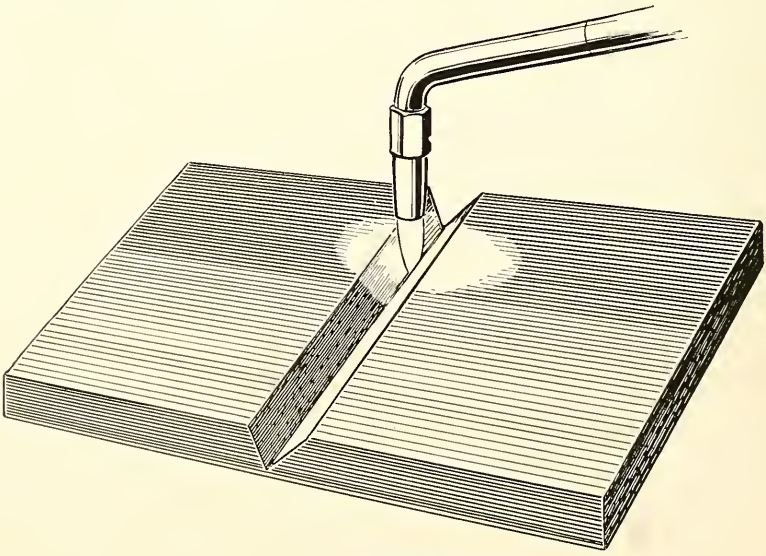


PLATE 28

a short distance from the surface, until the metal becomes red in the vicinity of the weld for a distance about three times as wide as the metal is thick.

Then we bring the cone down as shown in Plate 28 until the end of it just touches the surfaces to be joined. Note this carefully, since steel is the ONLY metal with which we bring the cone INTO ACTUAL CONTACT. On all other metals we hold the cone a little distance away. Do not make the mistake of bringing the tip of the torch to the metal—hold the torch so that the end of the cone just LICKS the surface.

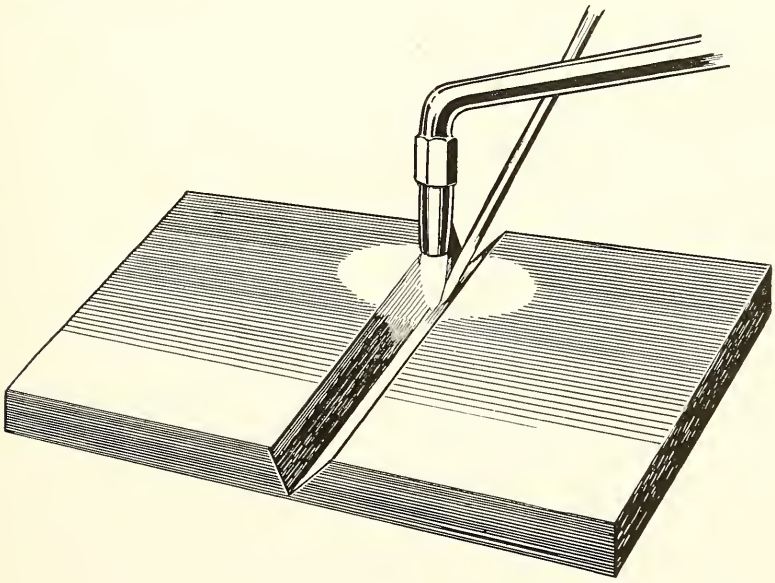


PLATE 29

As the bottom of the bevel melts together, the welding rod is brought down until it touches that spot and a small portion of it is melted while it is in contact with the material, as in Plate 29.

Now, we fuse this small portion to the material by a short circular motion, making sure that the flame actually comes into contact with every portion of it and that it is thoroughly fused to the material and that it has penetrated. As we finish the circular motion, we start melting the spot immediately adjoining.

Unlike cast iron, steel does not remain a liquid—it solidifies almost the instant the flame is removed, and it is for this reason that we are able to weld it in a vertical or overhead position, as well as horizontal.

If there is an excess of sparks, the flame is improperly adjusted and contains an excess of oxygen. If the metal melts too rapidly and is difficult to control, the tip is too large. If it does not keep in fusion and there is difficulty in getting the welding rod material to actually fuse to the article, the tip is too small. The beginner will be troubled with the welding rod sticking to the metal—don't attempt to pull it away; let it stay there until it is necessary to melt a portion of it in the weld.

Steel welding on a commercial scale should never be attempted until after the operator has proved to his own satisfaction that the weld is strong by welding together mild steel plates of one-eighth to one-quarter inch, sawing them through the weld to make sure that the material is really bonded and testing them by bending back and forth in a vise.

The practice of twisting several pieces of wire together to form a welding rod is not a good one, since this exposes more surface to oxidation or burning and for the same reason have the rod in contact with the material welded as it is added to the weld, so the article will prevent burning by its ability to conduct the heat away from the rod.

In welding two pieces of unequal thickness, we must bear in mind suggestions previously given—that the large piece requires more heat than the smaller one, and that care must be used to cool equally to prevent strains.

MEDIUM AND HARD STEELS

With the increase of carbon content, welding becomes more difficult, yet by no means is it impossible, even on those steels containing a large percentage. Whether or not we should employ the oxy-acetylene flame depends entirely upon our skill and the use of the article welded. Crank shaft welding is usually practical, if we are proficient; yet most crank shafts have a high carbon content. But it is by all means the best practice to become a good mild steel welder before attempting higher carbon steels.

To prevent, as far as possible, decarbonization, we should use the cast iron flux on steels of high carbon and a welding rod of a higher carbon content if we want about the same hardness. If the bond be one which will bend without harm, use a mild steel welding rod, since it is easier to make a weld of this character. Common steel may be welded to tool steel—for instance, an auto spring may be welded with high carbon steel, if retempering is necessary; but if broken on the end, it may be welded with mild steel with good results. The welding

of steels of high carbon call for a great deal of skill and it is impossible to lay down any hard and fast rule governing all cases. After we have become good mild steel welders, we are usually able to determine whether we should or should not weld steels of higher carbon.

ALUMINUM

While aluminum has a melting point less than half that of steel, its conductivity is over three times as great, so we use a tip about the same size for this metal as we do for steel, and because of this conductivity, we should realize that the effects of expansion and contraction must be particularly guarded against, since there is a large area which is heated and expanded and consequently a large area which must cool and contract.

The manufacture of sheet aluminum articles is daily becoming larger—the requirements in preparation practically the same as for iron or steel sheets, with the addition of a proper flux.

Aluminum castings vary in their composition, and success in welding them will depend somewhat upon the alloy used. Copper increases the strength, but machine work is made difficult; many times there is a large percentage of zinc, which makes machine work easy, but the casting is more or less brittle. An aluminum case, welded without attention paid to the effects of expansion and contraction, may distort or it may break—it depends upon the alloy used. The first consideration in aluminum repair work is expansion and contraction. We have previously studied this principle and should realize its importance, remembering that with aluminum the shrinkage is a great deal more than the metals we have already dealt with and warpage or breakage are certain unless we understand it. Plan, then, to heat and cool slowly and evenly.

Oxidation takes place very easily—more so than with other metals—and this oxide has a very high melting point. As the metal comes to the melting point, this oxide forms a film which prevents the edges flowing together and it must be destroyed before a bond can be effected. The method generally practiced by experienced welders is to destroy this oxide by means of a small iron rod or paddle and the edges joined by puddling the metal with this rod. This method is the cheapest, but it calls for the exercise of considerable skill and is not so effective as the destruction of the oxide by a flux, since it introduces the oxide into the weld.

Beveling aluminum is not so important as other metals, since the action of the flame causes the edges to slightly draw apart from each other. At this moment, the welding rod coated with flux, the same as with cast iron, is added, the flux chemically removes the oxide and the edges are bonded and material added from the rod at the same time.

With aluminum, we are especially likely to cause the metal to collapse because the heated area, due to the high conductivity, is large and the metal is without "strength" when it is very hot. For this reason, it is advisable for the beginner to make a mould consisting of approximately two-thirds asbestos fibre and one-third plaster paris to back up the broken section. Have this mould about one inch thick and let it dry thoroughly before starting to weld. Asbestos paper or ordinary paper may be put between this mould and the case if desired and if this will help in keeping dirt out of the weld.

How hot shall we preheat aluminum castings? It depends upon the alloy used. Ordinarily, a safe rule to follow is to stop heating when the casting gives off a dull sound when tapped lightly with a hammer. We can tell little by its color, as we can with iron and steel and even with the welding flame playing upon the break, it gives practically no warning that it is in a melting condition, other than when it is ready to add the flux and welding rod, it has a wrinkled appearance, dull grey in color.

Special care must be given to even heating, since most castings have bosses thinner or thicker than adjoining sections and we are likely to melt the thin part unless we particularly guard against it, or, on the other hand, not give the heavy section enough heat and so cause an unequal expansion.

Remember that aluminum must be carefully supported when preheating, since it is very brittle when hot, and as well keep it protected from draughts, as with other castings.

Aluminum is not a difficult metal to weld—the difficulty lies in properly taking care of expansion and contraction, and if we study this subject carefully, we will avoid many of the failures of the beginner.

In finishing the welded section of an aluminum casting, the ordinary wheel quickly fills up with chips. If this wheel is kept well oiled with a heavy lubricant, to a large extent this will be overcome. Ordinary files are useless and a Vixen should be used.

COPPER

Copper conducts heat more rapidly than any other commercial

metal. It will oxidize very easily and this oxidation is not easily apparent to the operator, but the weld becomes very brittle. The melting point is under that of steel and iron, yet because of its high conductivity a larger tip for the same size material is necessary. Cold, copper is very ductile; hot, it is brittle; so care must be used in its welding, since at a high heat it is very likely to fracture, either at the weld or some distance away, since the heat is conducted so rapidly that the temperature of the metal some distance from the weld is but little less than at the weld.

The metal should be prepared for welding the same as others—the V properly made, and the metal thoroughly clean. Besides the advantage of preheating to prevent contraction cracks or strains, owing to the high conductivity of copper, it will cheapen the welding operation considerably to heat it by other means than the oxy-acetylene flame.

The welding of copper is quite difficult to realize and maintain ductility. A special welding rod is necessary containing an element opposing the action of oxygen on the copper and a flux for the same purpose as well. The cone should not come in direct contact with the metal at any time.

For repair purposes, it is sometimes impossible or impractical to weld the break, and we then braze it, either with brass or bronze, using the brass flux for this purpose and following the same general directions as for brazing malleable iron.

BRASS AND BRONZE

Brasses and bronzes are composed of copper, with lower melting metals as alloys, zinc, tin, etc. Since these metals have different melting points, considerable care must be exercised in welding not to change the character of the metal too much by burning out these alloys.

The metal should be prepared the same as any other, with particular care in setting up to prevent moving while being welded and to prevent collapse of the heated area. The metal should not be brought to fusion by bringing the cone in contact with it, but as with copper, the end of the cone should be slightly above the metal. For repair purposes, Tobin bronze or brass should be used for the welding rod—for foundries or in manufacturing where the weld must be practically the same color and the same material as the metal, more judgment is necessary in the choice of the rod, with a view of replac-

ing, by means of the material in the welding rod, those metals burnt out of the line of welding by the flame.

MISCELLANEOUS METALS

Galvanized Iron—Cannot be welded, since the iron is covered with and to a greater or less extent impregnated with, a lower melting metal.

German Silver—In many cases considered unweldable, due to its absorption of gases. For practically all commercial purposes, it may be bonded, using the same flux as for brass and a strip of German silver for the welding rod. Especial care must be given to expansion and contraction.

Nickel—Extremely difficult to weld, but in many cases not impossible. Anodes, used in nickel plating, may be fused together without flux and while there are considerable blow holes in the bond, the conductivity is little affected. Where a bond is required free from blow holes, it is possible to effect it by a combination of the blacksmith weld with oxy-acetylene.

White Metal—Castings used for die moulded purposes usually are composed of aluminum, tin and zinc in varying proportions, but nearly always with the lower melting metals in the larger proportion. While the castings have a good deal the same appearance as aluminum, they are considerably heavier. They may be considered unweldable.

Lead—Is perfectly feasible. The objection here is on the ground of heat; i. e., the oxy-acetylene flame is too hot. This merely calls for speed on the operator's part and this metal is easily joined. The most successful flame for lead burning, however, is oxygen-hydrogen, for which special apparatus is furnished. See Page 52.

Different Metals—Sometimes we are required to bond two different metals. Cast iron may be welded to iron or steel, for instance. The bond is brittle, to be sure, but sometimes this is not an objection. Some authorities recommend the use of Norway iron as a welding rod, but we would prefer using cast iron.

Copper may be bonded to cast iron or steel, with copper used as a welding rod. Brass to copper, using brass as a welding rod, etc.

FIGURING COSTS

The high pressure oxygen gauge is registered in pounds. All oxygen cylinders are charged to a pressure of 1,800 pounds and at that pressure contain 100 cubic feet or 200 cubic feet, depending upon the size used. The pressure, however, is the same in all cases.

The Imperial torch uses practically equal volumes of oxygen and acetylene, so it is only necessary to determine the cubic feet of oxygen used and estimate the same number of cubic feet of acetylene to determine cubic feet of both gases.

As we know the cost per foot of each, F. O. B. the factory, it is necessary only to add freight or expressage to find out the cost per foot in the shop, and we are then in a position to figure exactly the cost of both gases on any job.

The gauge pressure on the acetylene cylinder DOES NOT indicate cubical contents. As acetylene is dissolved in acetone, the contents of the cylinder varies with the purity of the absorbent and its volume. Temperature is also an important factor—in the winter a full cylinder will register, say, 150 pounds, and in the summer may register 300 pounds. We can determine the contents by weight, as there are 14½ cubic feet of acetylene in a pound. If a cylinder weighs, when received, 160½ pounds and when empty 145 pounds, we have used 15½ pounds of gas. Multiplying this by 14½ we have 224¾, which is the number of cubic feet.

This procedure is not necessary to estimate costs, since we can figure acetylene consumption by our oxygen gauge reading. It is advisable at intervals, at least, to check up the invoices in this manner to see we are getting the exact amount of gas for which we are paying.

On Page 44 is a suggestion for a cost card, the principles of which may be adapted to your particular requirements. Overhead is largely a matter of local conditions, but in a repair shop it would be wise to figure this overhead at a fairly high percentage.

SUGGESTION FOR COST CARD

Oxygen gauge, start	1800 lbs.	=	100 cu. ft.
Oxygen gauge, finish	900 lbs.	=	50 cu. ft.
Oxygen used	900 lbs.	=	50 cu. ft.
Acetylene used—			
50 cubic feet @	2½		$1.25
Oxygen used—			
50 cubic feet @	2		1.00
PREHEATING COST			
Charcoal			
Gas, ½ hour, 2 burners @	60		.30
Kerosene			
LABOR (Preparing)—			
1 hour 30 min @	60		.90
LABOR (Welding)—			
1 hour 30 min @	60		.90
LABOR (Finishing and testing)—			
1 hour min @	30		.30
RODS—			
Lbs. Steel @			
15 Lbs. Cast Iron @	10		1.50
Lbs. Bronze @			
Lbs. Copper @			
Lbs. Aluminum @			
FLUX—			
½ Cans Cast Iron @	50		.25
"			
"			
"			
"			
Total			$6.40

REMARKS .....

CUTTING WITH IMPERIAL APPARATUS

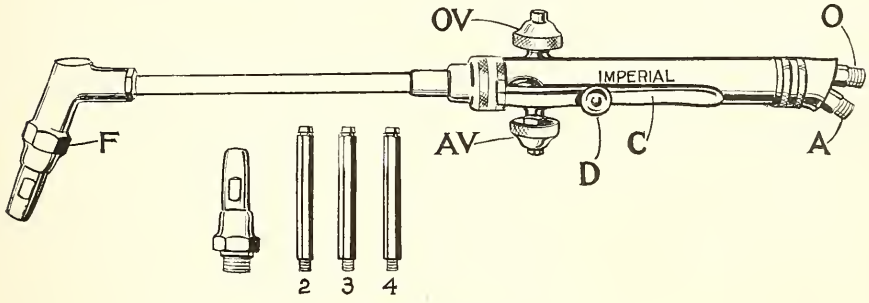


PLATE 33

Imperial Cutting Torch—Type E

A—Acetylene Inlet. AV—Acetylene Valve. C—Lever Operating Valve for Oxygen Cutting Jet. D—Thumb Screw. F—Removable Housing that protects Cutting Tips. O—Oxygen Inlet. Nos. 2, 3 and 4 are Cutting Tips.

SETTING UP APPARATUS

The same general care is required for the cutting equipment which has been outlined for the welding apparatus, particular care being given to tight hose connections and valves which will not leak, since the oxygen is used at a higher pressure and a leak, in combination with the flying sparks, is likely to cause a serious burn.

The oxygen hose is attached to the upper tube, as with the welding torch, and the acetylene to the lower. The pressure used on the oxygen line is considerably higher than in welding, since we need an excess of oxygen, which is conducted through an inner tube, to OXIDIZE or burn the metal.

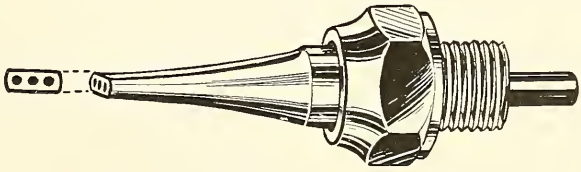


PLATE 30

SPECIAL IMPERIAL TIPS FOR STRAIGHT CUTTING

For cutting of plates, I-beams, etc., where the line of cutting is always straight, we have designed a special flat tip, with only two preheating flames (Plate 30). By this method a smaller surface of the metal is being preheated, a narrower, smoother cut results and a considerable amount of gas is saved.

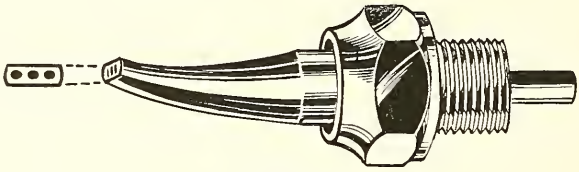


PLATE 31

SPECIAL IMPERIAL TIP FOR RIVET CUTTING

For rivet cutting we furnish a flat tip slightly curved, which allows quick and clean cutting of rivets without injury to the plate.

These tips are furnished on application with regular Cutting Outfits.

SELECTION OF CUTTING TIPS

Each Imperial cutting tip is marked on the flat sides with letters and numbers to indicate size of tip, thickness of metal it will cut, pressure in pounds and kind of gas. For example: Cutting Tip No. 1 has the figure 1 on one side, meaning size No. 1; on next side are ⅛ and 3, meaning it will cut wrought iron or steel from ⅛″ to 3″ in thickness; on the next side is A-15, meaning the small acetylene gauge should register 15 lbs., and then the marking O-70, which means the small oxygen gauge should register 70 lbs.

Note that the markings A-15 and O-70, referred to above, indicate the MAXIMUM gas pressures needed for cutting the thickest metal that particular size of tip is intended for. To illustrate: When cutting ¼″ or thinner metal with the No. 1 tip, an acetylene pressure of about 10 lbs. and an oxygen pressure of about 40 lbs. are required. These pressures are varied according to the thickness of the metal and the conditions to be met.

Select the proper size of cutting tip according to the thickness of metal to be cut as follows:

Thickness of Metal.....	¼″ to 3″	3″ to 6″	6″ to 9″	9″ to 12″
Size of Tip to Use.....	No. 1	No. 2	No. 3	No. 4

After screwing the tip into the torch, screw the housing (F) down and be sure the face of the housing is flush with the end of the tip.

The preheating flame is adjusted exactly the same as for welding, but in this case we have six small flames instead of one and we must control the adjustment by means of the shut-off valve on the torch. The valve with the lever handle is the one which controls the independent oxygen supply, the one which does the cutting, and which comes down in the center of the tip. This is a diaphragm control, shutting off the gas when the lever is pressed down and open when the lever is allowed to spring up. A small knurled wheel controls the

distance this lever moves and may be adjusted by the operator. A cutting torch is simply a welding torch with an added tube through which comes oxygen alone under pressure to oxidize the metal.

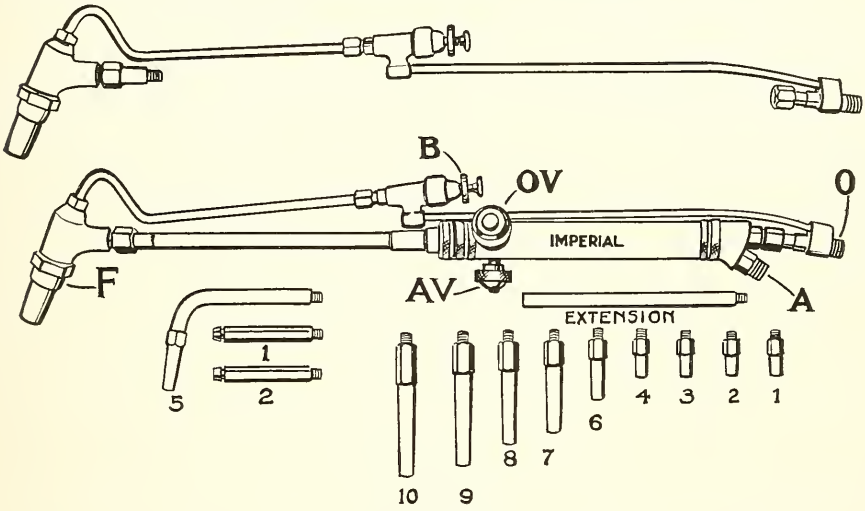


PLATE 32

Imperial Combination Welding and Cutting Torch

A—Acetylene Inlet. B—Valve for Oxygen Cutting Jet. AV—Acetylene Valve. OV—Oxygen Valve. F—Removable Housing that protects Cutting Tip. No. 5 Tip is attached to Welding Head. O—Oxygen Inlet. Nos. 1-10 on right are the Welding Tips. Nos. 1 and 2 on left are Cutting Tips. Cutting Attachment removed is shown at top of illustration.

In combination with the welding torch, the Imperial Brass Manufacturing Company also furnish an attachment for cutting, which can be attached to the welding torch, as shown in Plate 32. Here the lever control is supplanted by a push button, the principle of which is exactly the same as the lever control of the cutting torch.

In planning the job, have the tanks firmly secured to prevent tipping over and hose BEHIND you so as to protect it as far as possible from damage due to flying sparks. Make certain also that the hose is not in a location where it may be cut or otherwise damaged.

PRINCIPLE OF CUTTING

Beginners often mistake cutting for melting. Since the only visible agency to do work is the flame, it is assumed that the flame is melting the iron or steel. This is not so, however. Previously we have spoken of oxidation and how we must guard against it in welding; that oxidation is the burning of a metal and takes place by oxygen uniting with the metal and forming an oxide. Cutting, then,

is simply the rapid oxidation or burning of the metal and the flame is used merely to get the metal hot enough so that it will oxidize quickly.

Since all metals are subject to oxidation in welding, it is natural to assume that all metals could be cut by means of oxygen from the cutting torch; but this is not so, and we are limited to those metals where the oxide is of a lower melting point than the metal itself, this being the case in wrought iron and steel. Other metals, such as cast iron, aluminum, copper, brass, etc., cannot be cut.

The flame is of use simply to get the metal hot enough so that oxidation takes place rapidly; the oxide having a lower melting point than the metal, runs off the metal and leaves a new surface exposed to the cutting jet of oxygen. Once started, this oxygen jet theoretically should be sufficient to keep up oxidation, since there is considerable heat created—the oxygen being the supporter of combustion and the metal the fuel—in other words, the metal is burnt up, but because the stream of oxygen is small, this burning is confined to a narrow area. We need the flame because other influences, scale, dirt, the air, sand, blowholes, etc., may stop this oxidation and the flame then heats the metal to a sufficient point to again start oxidation.

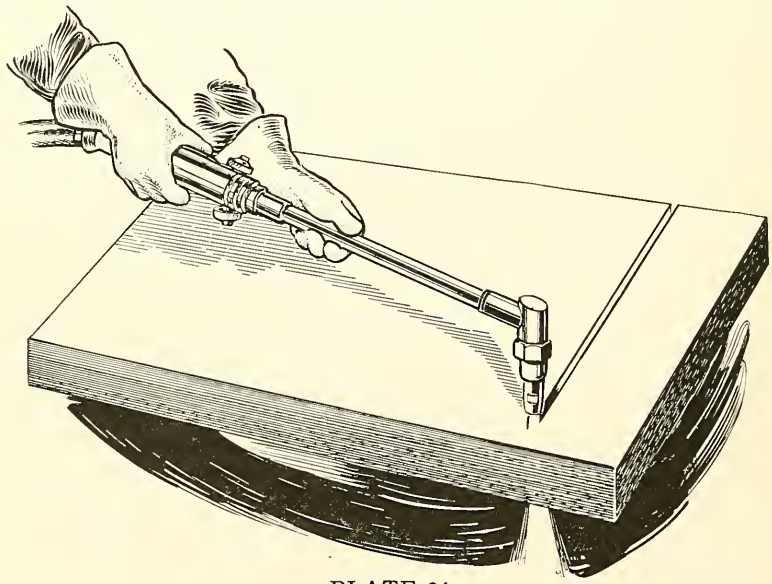


PLATE 34

HOW TO CUT

When the flame is adjusted, as described above, hold the torch as shown in Plate 34, the left hand grasping it well toward the head and

the right hand on the handle with the fingers controlling the lever valve. The elbow or forearm should rest on the material being cut whenever possible to steady the torch. When we are cutting free hand, that is without the wheel guide, IT IS DESIRABLE TO ARRANGE TO CUT EITHER RIGHT TO LEFT OR LEFT TO RIGHT—not toward or away from the operator.

Start on an edge—not in the center of a plate—whenever it is possible. Now hold the flame on the edge until it gets to a white heat; release the lever valve and the oxygen immediately starts burning the metal. Hold the torch steady until the cut goes through—then move the torch along the line to be cut with a steady movement—not a jerky one. WATCH THE DIRECTION OF THE SPARKS. If they fly in the direction as shown in Plate 35, the cut is not going through. At the start, they should appear about as shown in Plate 36. Then the torch head is slightly inclined TOWARD THE DIRECTION WE ARE CUTTING.

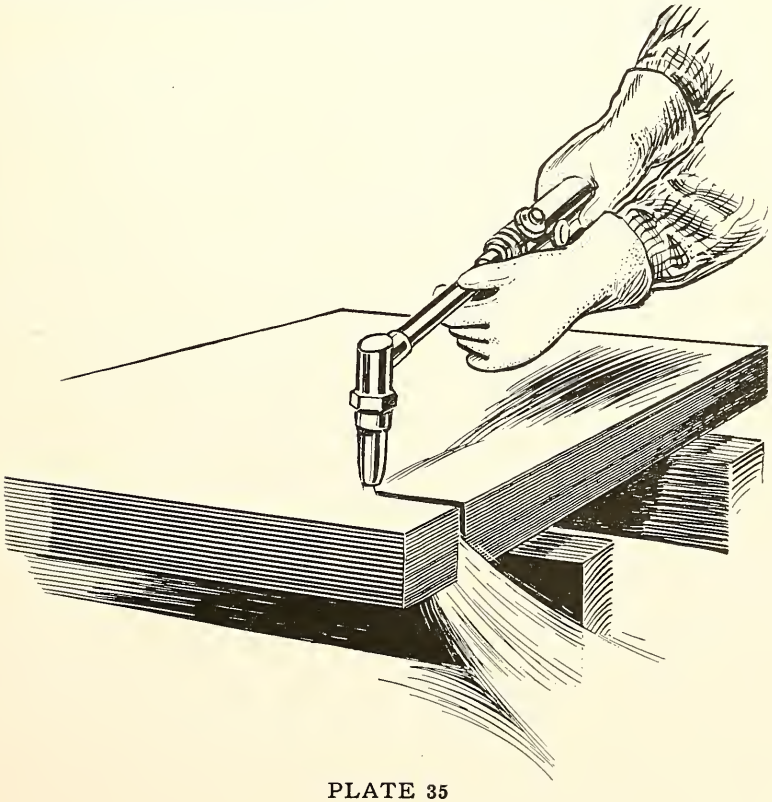


PLATE 35

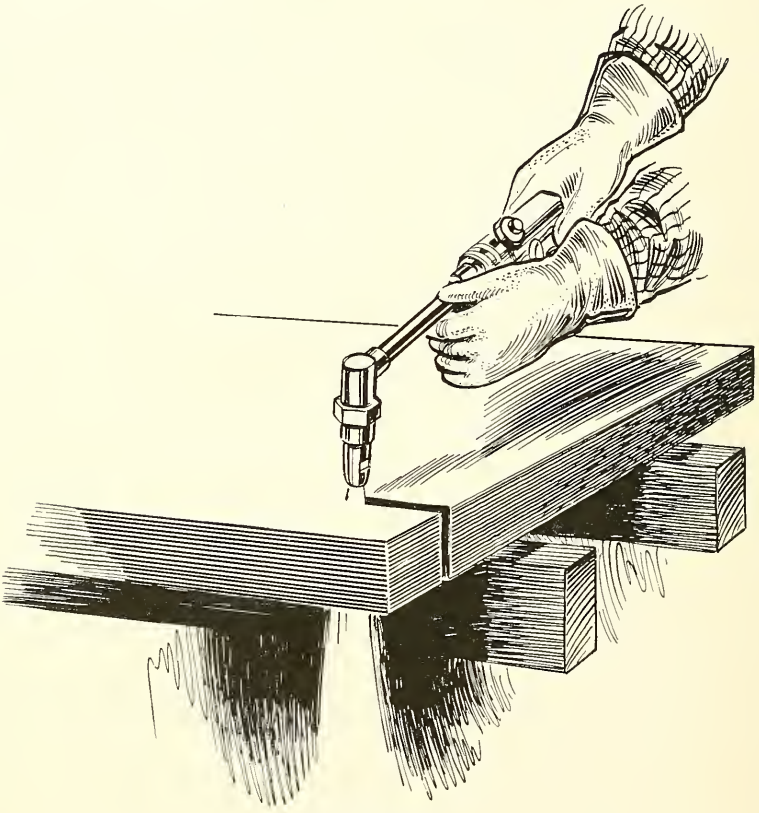


PLATE 36

Previously we have remarked that various reasons cause the stopping of oxidation. The chief reason (for beginners, at least) is the unsteadiness of the hand. Just the moment this oxidation stops, use the right hand to close the lever valve on the oxygen supply, then start heating an edge exactly the same as in the beginning of the cut and when at the white heat again release the lever valve and start cutting.

When the cut to be made must be reasonably smooth, use the wheel guides, and if a straight line must be followed, clamp a suitable bar of metal to the article to be cut, as shown in Plate 37.

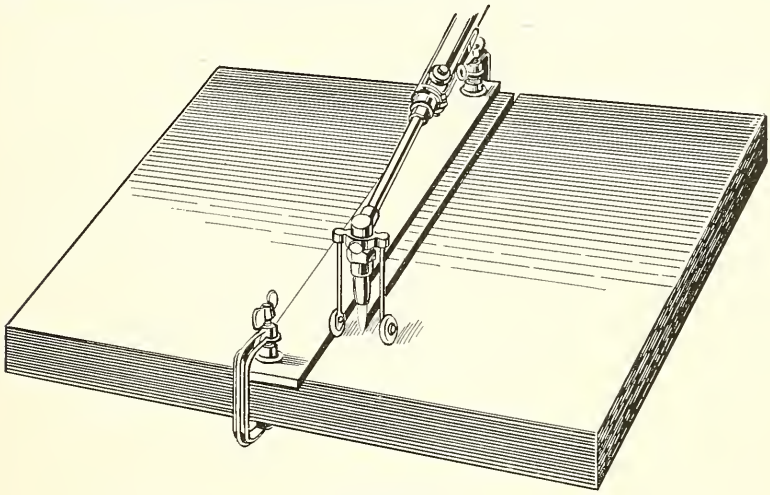


PLATE 37

GENERAL HINTS ON CUTTING

Hold the flame so that the end of the cone just licks the metal—don't attempt to plunge it down into the cut.

When cutting two plates or more, or where there is a lap joint, remember that there is more or less of an insulation (air, dirt, etc.) between these plates and that the oxidation cannot be as fast as where only one thickness is cut. THE SLIGHT TIPPING OF THE TORCH TOWARD THE DIRECTION TO BE CUT IS A HELP IN CUTTING MORE THAN ONE THICKNESS.

Remember that the flame does not do the cutting—therefore, work with the smallest flame possible—it means a neater cut.

Keep the oxygen pressure as low as possible and yet maintain speed. A high pressure is spectacular and there are a great number of sparks, but it is not economical and a wider scarf is made.

Don't use the torch with greasy gloves—a spark in combination with a leak on the oxygen supply will badly burn the hand.

If a cut must be started in any place except on an edge, drill a hole or use a cold chisel and a hammer to roughen up the surface, the idea being to get an edge to quickly start oxidation.

POINTS TO BE OBSERVED

Never use oil or lubricant of any kind on tank valves, gauges, regulators or other fittings, as this may result in spontaneous combustion and explosions.

Be careful that there are no leaks in any of the connections, or in the rubber tubing, and that the torch tip is free from obstruction.

Always have an ample supply of gases, before commencing a job, as it is injurious to stop in the middle of the work.

It is necessary to wear tinted glasses or goggles to prevent eye strain.

In doing heavy work, if the burner is used continuously for a long time, or held in a confined space, it will become heated. In such cases, turn off the gases and dip the torch head into cold water.

When working inside a boiler or tank, or any small enclosure, two operators should be employed, so that one will be available to quickly turn off the gases in case of accident, such as the bursting of the hose.

No one but a thoroughly instructed, experienced operator should attempt boiler welding.

We believe the time will soon come when the officials of shops will require a Certificate of Competence from every operator who is entrusted with that kind of work, and The Imperial Brass Manufacturing Company is opening a school with competent teachers to qualify students for every kind of welding and cutting.

In very heavy welding, two operators should be used, so that one can relieve the other, and the work continued until finished without interruption.

An excessive discharge of sparks indicates that too much oxygen is being used, and that the metal is being burned or oxidized. In very heavy welding, there will, of course, be a considerable volume of spark even when the flame is neutral.

Butt welding is preferable to lap welding and easier to perform.

In clearing the torch tips, do not use steel; employ copper or some other soft metal.

Never tighten up regulating screws on either regulator except when tank valves are open, as otherwise you might distort the diaphragm.

OXY-HYDROGEN PROCESS

The foregoing directions are applicable specially to the use of oxygen and acetylene gas for welding and cutting.

Imperial Torches are also adapted for the use of hydro-carbon gases and of hydrogen in connection with oxygen gas for welding and cutting.

Special tips and special regulators are furnished for these purposes with Imperial Equipment on request.

We do not recommend welding of steel above ¼" and of cast iron

above ¾″ in thickness with anything but acetylene and oxygen, but for welding of light sheet steel of No. 16 gauge and up, light cast iron and especially aluminum, the oxy-hydrogen process offers many advantages provided the hydrogen can be purchased at a reasonable price.

The oxy-hydrogen flame having a temperature of about 4,000° F., the metal is not so easily burned, and as hydrogen contains no carbon, the weld is softer and very uniform.

In welding with oxygen and hydrogen, the torch has to be held somewhat further away from the work than is practiced in oxy-acetylene welding, because the flame is not so pointed and less concentrated.

When a black spot appears in the weld, it proves that the torch is too near the work and the distance has to be slightly increased. Otherwise the same directions given in the former chapters on oxy-acetylene welding apply also on oxy-hydrogen welding and an experienced oxy-acetylene operator will soon become proficient in this branch of his trade.

For cutting of steel and wrought iron, the oxy-hydrogen flame is decidedly superior to the oxy-acetylene flame. Hydrogen does not deposit carbon products in the seam, it lessens the formation of slag, therefore a much cleaner and smoother cut results and much thicker material can be cut with the same amount of gas.

A drawback to the novice in the use of hydrogen is the circumstance that the hydrogen flame is not easily visible and it seems harder to properly adjust the flame. However, Imperial tips are all marked with the required gas pressures and the operator quickly gets used to the different conditions.

CARBON BURNING

We have already learned that oxygen and carbon have a great affinity for each other; that is, that oxygen will unite with carbon very easily. Carbon in a cylinder of a motor is caused by imperfect combustion—it may be there because the carburetor was not adjusted properly to give sufficient air or it may be because too much oil was used in proportion to the air. If the motor had received enough air, it would not be there, and since the element in the air necessary to completely burn it is oxygen, we may remove it quite easily by the use of oxygen.

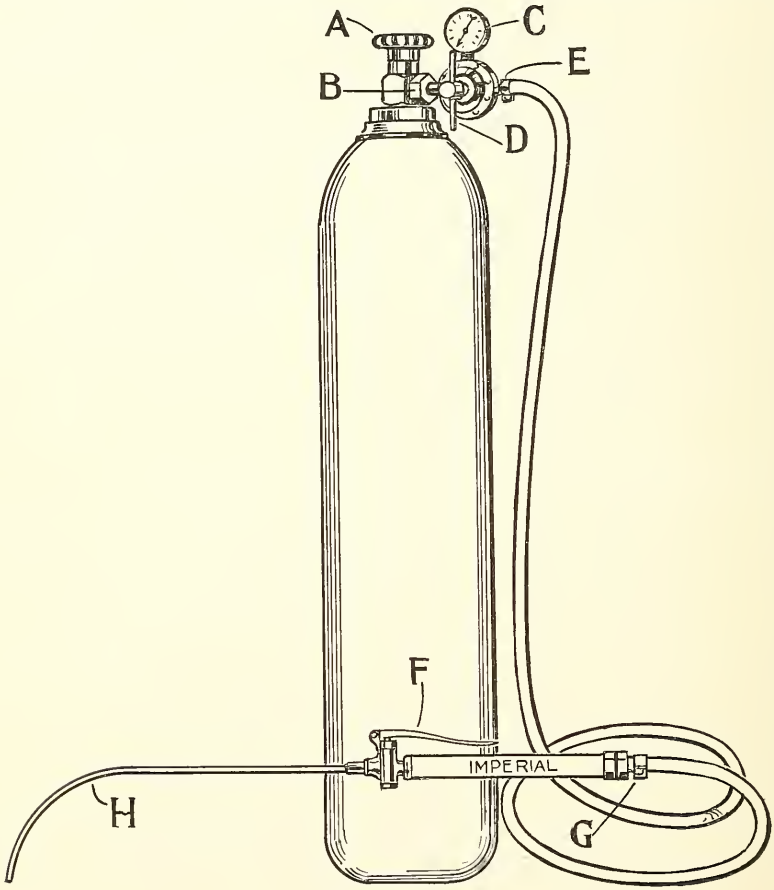


PLATE 38

Imperial Decarbonizing Outfit

A—Oxygen Tank Valve. B—Tank Coupling. C—Pressure Gauge showing pressure delivered to Torch. D—Regulating Screw. E—Hose Connection. F—Trigger Valve. G—Hose Connection. H—Flexible Copper Tip.

THE APPARATUS

The Imperial Carbon Burning Equipment consists of one oxygen regulator with gauge and the decarbonizing torch with hose.

REMEMBER THAT OXYGEN ALONE IS NECESSARY TO DO CARBON BURNING—NO ACETYLENE BEING EMPLOYED.

Connect the oxygen regulator to oxygen tank and the hose at one end to outlet E of the regulator and at the other end to the carbon burning torch G.

Now, with the motor running, shut off the gasoline and allow the engine to run down. If the engine is particularly dirty, it may be advisable to protect the carburetor and pan by placing some asbestos paper at points to prevent fires from flying sparks.

Remove spark plugs from cylinders—not the valve caps. Crank the motor until the cylinder to be started upon has the piston at the top, with both valves closed.

Set the pressure on the regulator at about fifteen pounds and PARTIALLY depress the lever on the handle of the carbon burner.

Use a wax taper or drop a lighted match into the spark plug opening of cylinder, at the same time directing the copper tube of the carbon burner at that point. This ignites the carbon, and if it is not too dry, the oxygen should thereafter be sufficient to completely consume it without again lighting it. At the start, particularly if the cylinder is oily, there will be some flame as well as considerable sparks. Hold the pressure down until the flame has practically disappeared, press down the lever all the way and move the tubing back and forth around the walls until sparks stop.

Sometimes the cylinder is very dry and the carbon is rather difficult to burn. This can be more or less determined by the appearance of the spark plug. If it is dry, squirt about a teaspoonful of kerosene into the cylinder, spreading it over as large a surface as possible, to AID the burning.

The tube is flexible and may be bent as desired to reach any portion of the cylinder. Actual contact with the carbon by the tube is not necessary to consume it—carbon burns in an atmosphere of oxygen after it is ignited.

The only possible danger to the cylinder, valves or piston is a too high pressure of oxygen on an extremely oily cylinder—there would be considerable heat generated in this instance. Hold the pressure down, then, until the flames have gone and sparks only are being thrown out before opening the lever on the handle full.

When through cleaning, it is desirable to remove the valve cap and blow out any solid particles there may be present; these solid particles cannot be carbon, but may be graphite, pieces of iron, etc. The appearance of the cylinder will be considerably improved by swabbing off the top of the piston and valves with an oily rag.

Carbon burning is a very practical solution of carbon deposits—care and horse sense must be applied, however, though the process calls for no particular degree of skill.

With every Imperial Welding Outfit a decarbonizing torch is furnished. For removing carbon from engine cylinders it is only necessary to connect this torch with the regular oxygen hose and to follow otherwise the directions given above.

INDEX

Beveling 22
Carbon Burning 53
Care of Apparatus 7
Champfering 22
Contraction of Metal 15
Costs, Figuring 43
Cutting 45
Expansion of Metal 15
Flash Back 13
How to Hold Torch 24
Oxy-Hydrogen Process 52
Regulation of Flame 21
Regulators, Acetylene 12
" Oxygen 8
Tips, Selection of 26
Torch, Combination 47
" Cutting 45
" Welding 12
Welding, Aluminum 39
" Brass and Bronze 41
" Cast Iron 27
" Copper 40
" Malleable Iron 32
" Medium and Hard Steel 38
" Miscellaneous Metals 42
" Preparation for 34
" Steel and Iron 33

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